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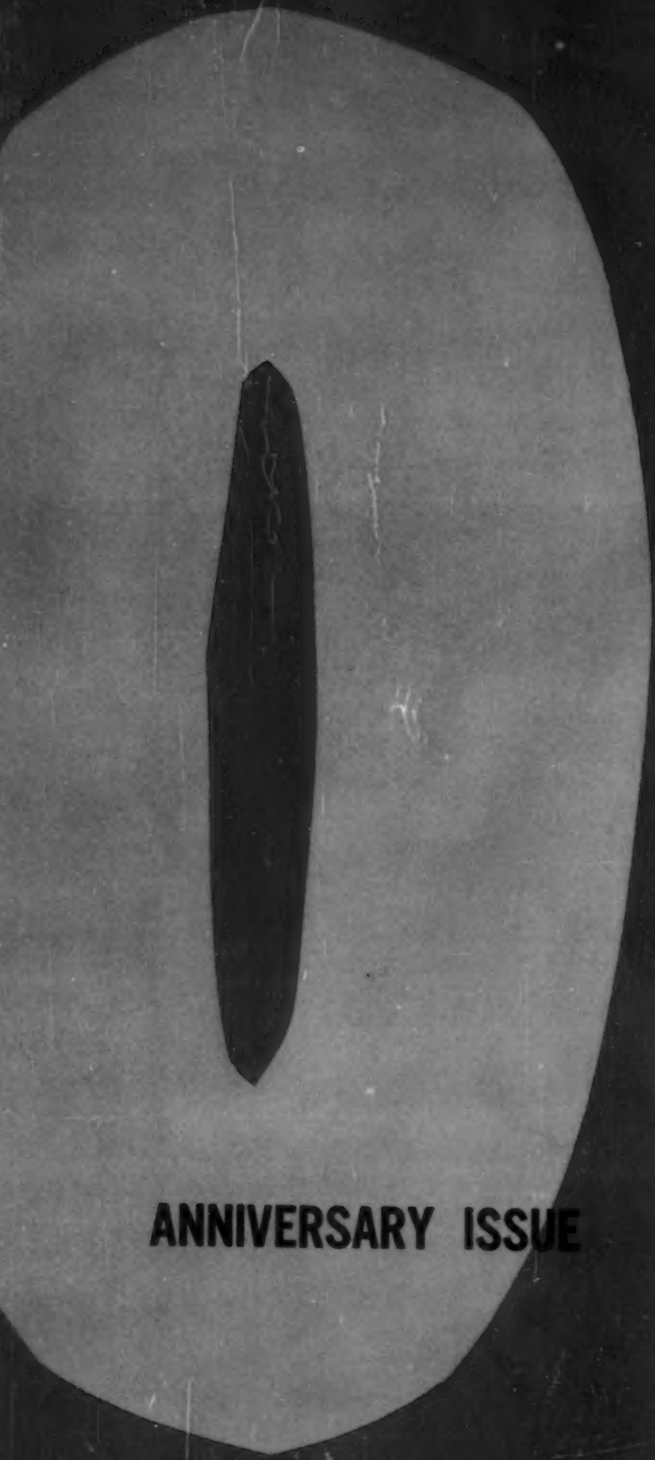
JANUARY 1959



ANNIVERSARY ISSUE

COMING EVENTS

Jan. 12, AIME Minnesota Section, annual meeting, Duluth.

Jan. 13-14, Annual Mining Symposium, University of Minnesota, Duluth.

Jan. 15, AIME Utah Section, speaker: H. Wright; subject: Rubber and Plastic as Cost Savers in Metallurgical Installations; Salt Lake City.

Feb. 5-6, California Governor's Industrial Safety Conference, Biltmore Hotel, Los Angeles.

Feb. 5-7, Centennial Celebration and Mining Convention, sponsored by Colorado Mining Assn. and others, Denver.

Feb. 15-19, AIME Annual Meeting, Sheraton-Palace, St. Francis, Sir Francis Drake Hotels, San Francisco.

Feb. 23-27, Fluidized Reactor Course, University of Arizona, Tucson.

February, AIME Lima, Peru, Section, subject: panel review of Peruvian Geology, Lima, Peru.

Mar. 1-4, Canadian Prospectors & Developers Assn., annual meeting and convention, Royal York Hotel, Toronto.

Mar. 2-3, Fluidized Reactor Symposium, University of Arizona, Tucson, Ariz.

Mar. 16-19, 11th Western Metal Congress, American Society for Metals, Los Angeles.

Apr. 5-10, EJC 1959 Nuclear Congress, Public Auditorium, Cleveland.

Apr. 13-15, CIM, annual meeting, Queen Elizabeth Hotel, Montreal.

Apr. 16-18, AIME Pacific Northwest Regional Conference, Olympic Hotel, Seattle.

Apr. 18, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

Apr. 20-22, Third Rock Mechanics Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; Colorado School of Mines, Golden, Colo.

May 8-10, Fourth Annual Uranium Symposium, AIME Uranium Section, Moab, Utah.

May 11-14, American Mining Congress, Coal Show, Cleveland.

June 15 (approx.) AIME Pittsburgh Section—SME Coal Division, joint meeting, Waynesburg, Pa.

June 28-July 1, Rocky Mountain Coal Mining Inst., annual meeting, Antlers Hotel, Colorado Springs, Colo.

Sep. 14-17, American Mining Congress, Metal Mining & Industrial Minerals Convention, Denver.

Sept. 24-26, SME Industrial Minerals and Coal Divisions, joint meeting, Bedford Springs, Pa.

Oct. 8-10, Exploration Drilling Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; Pennsylvania State University, University Park, Pa.

Oct. 27-29, 1959 AIME-ASME Joint Solid Fuels Conference, Netherland-Hilton Hotel, Cincinnati.

Nov. 9-12, Society of Exploration Geophysicists, annual meeting, Biltmore Hotel, Los Angeles.

Dec. 7, AIME Arizona Section, annual meeting, Tucson, Ariz.

SOCIETY OF MINING ENGINEERS AIME

MINING engineering

Vol. 11 NO. 1 **JANUARY 1959**

COVER *This month's numerals are to remind you that MINING ENGINEERING with this 121st issue is marking its 10th anniversary (AIME is marking its 86th year of publication activity).*

ARTICLES

DEPARTMENTS

FEATURED ITEMS

Address insertion orders and copy to MINING ENGINEERING, 29 W. 39th St., New York 18, N. Y. Send plates to: MINING ENGINEERING, c/o Lew A. Cummings Co. Inc., 215 Canal St., Manchester, N. H. Published monthly by the American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., 29 W. 39th St., New York 18, N. Y. Telephone: PEnnsylvania 6-9220; TWX NY 1-1304. Subscription $8 per year for non-AIME members in the U. S., & North, South, & Central America; $10 foreign; $6 for AIME members, or $4 additional for members only in combination with a subscription to "Journal of Metals" or "Journal of Petroleum Technology". Single copies, $.75; single copies foreign, $1.00; special issues, $1.50 AIME is not responsible for any statement made or opinion expressed in its publications. Registered cable address, AIME, New York. Indexed in Engineering Index, Industrial Arts Index, and by National Research Bureau. Second class postage paid at New York, N. Y., and at Manchester, N. H. Number of copies printed of this issue 15,000.

PERSONNEL

THESE items are listings of the Engineering Societies Personnel Service Inc. This Service, which cooperates with the national societies of Civil; Electrical; Mechanical; Mining, Metallurgical, and Petroleum Engineers, is available to all engineers, members and nonmembers, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5 pct of the first year's salary if a nonmember, or 4 pct if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number. When making application for a position, include 8¢ in stamps for forwarding application to the employer and for returning when possible. A weekly bulletin of engineering positions open is available at a subscription rate of \$3.50 per quarter or \$12 per annum for members, \$4.50 per quarter or \$14 per annum for nonmembers, payable in advance. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18**; 57 Post St., **San Fancisco**; 84 E. Randolph St., **Chicago 1**.

MEN AVAILABLE

Manager or Mine Superintendent, B.Sc. in mining engineering, age 40. Experience for 18 years in mining engineering, exploration, mine plant construction, mine operation, management, and administration. Business and industrial management training included. Has had background in personnel selection, labor and contractual negotiations, corporate finance, and purchasing procedure. M-452.

Mining Geologist, recent graduate with B.S. in mining geology and M.S. in geology. Single. Two years work with U. S. Army Corps of Engineers as civil engineer (officer). Desire foreign location. M-453.

Manager or Superintendent, B.S. in mining engineering, age 40, married, no children, B.S. in mining engineering. Varied mining experience for 19 years doing exploration, engineering, designing, production, and administration; placer; underground and open pit; U. S. and South America. Speak Spanish and Portuguese. Desire responsible position with mining company, domestic or foreign. Available immediately. M-229-San Francisco.

General Superintendent, Assistant Manager, Exploration Manager, B.S., age 44. Experience of 20 years in base metals, gold, tungsten, etc., in mining and exploration, mainly in southwestern U. S. and Canada. Considerable experience in fluorspar examination and operation. Mostly underground mining. Registered in Arizona. Location, U. S. or Canada, preferably west. M-232-San Francisco.

Mining Engineer, B.S., age 36. Eleven years experience in all phases of open pit rail and truck operation. Fluent Spanish. Location desired, southwest or South America M-324-San Francisco.

Mining Engineer, E.M. degree, age 27. Experience: 2 years mining and underground surveying; 1½ years surveying, computing, and land work in public engineering offices. Prefer western U. S. or foreign. M-331-San Francisco.

Geologist, 30, B.S., and M.S. degrees, plus 6½ years in exploration for metallic and nonmetallic mineral deposits. Heavy property examination experience, geophysical exploration, field supervisory position, plus report writing. Seeking employment in mineral industry or related field with limited travel requirements. Now employed. M-454.

Administrative Assistant, Mining Engineer, with seven years experience including mining and plant operation; property and management evaluation, both foreign and domestic; market development; sales; and ore buying. Has had experience working for and with top management. Will travel and relocate. Interested in a responsible active position. M-455.

POSITIONS OPEN

Direct Sales Representative for manufacturer of heavy construction and mining equipment. Must be experienced in application of excavating and loading equipment. Sales experience desirable. Headquarters, New York. W6179.

Research Metallurgist, ore beneficiation, metallurgist, or mining engineer well trained in metallurgy, with aptitude and interest primarily research, to improve current practice in 100-tph copper flotation mill and to test various grades and mixtures of massive sulfide ores. Three-year contract. Salary, open. Submit complete record and references with first reply. Location, Mediterranean area. F5884S.

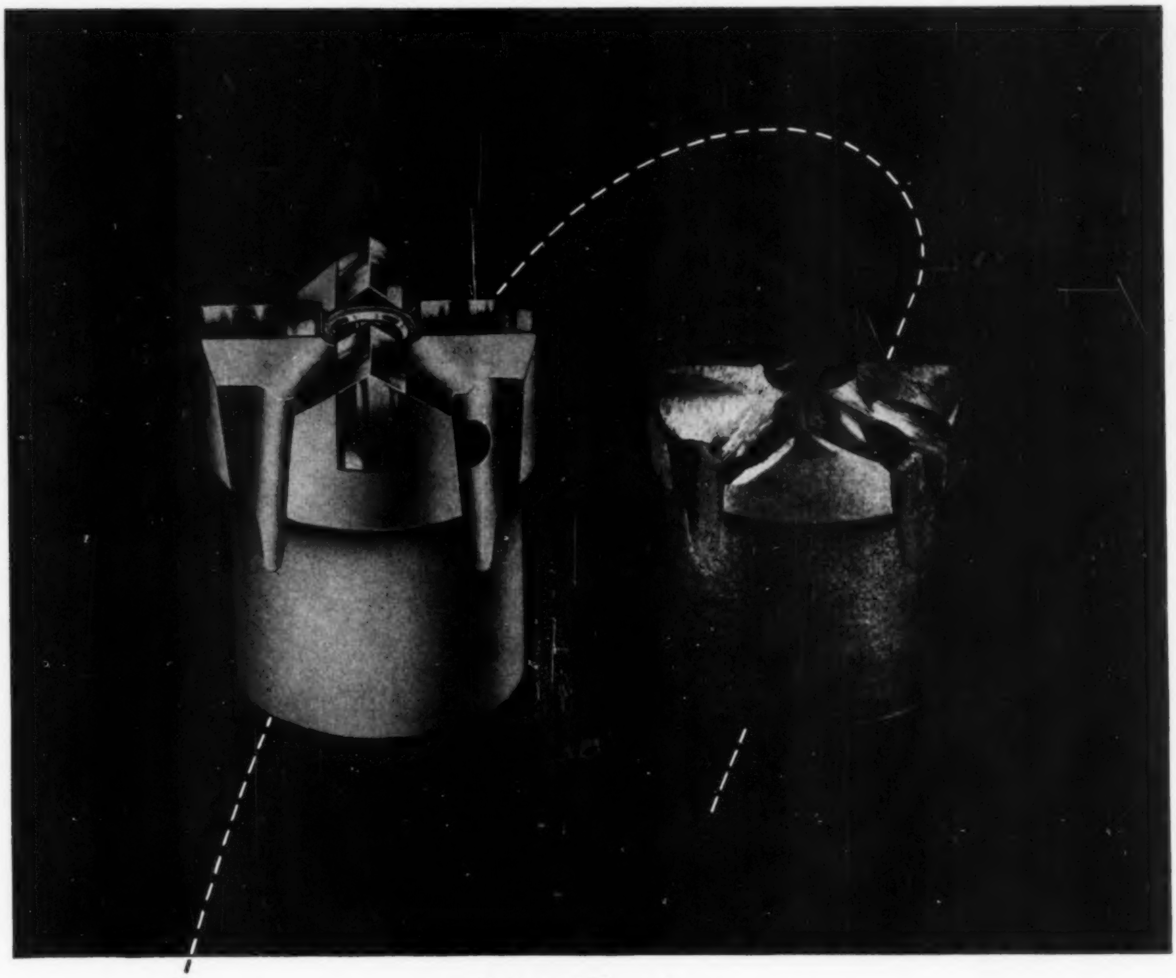
Process Engineer, B. S. in mining engineering, with major or minor in ore dressing, for combination field and laboratory process work with leading phosphate rock mining operation. Location, South. W5677.

Superintendent, Mining Engineer, for hard rock open pit, 25-man operation. Location, desert area, southern California. Salary, open. S3718.

Assistant to President, mining, chemical engineering, or business administration graduate, with at least seven years managerial or staff experience in metal mine production. Salary, \$25,000 to \$40,000. Location, New York. W6787.

Mine Master Mechanic, for mining and mill equipment; some knowl-

(Continued on page 92)



THIS JOY BIT DRILLED *46% Farther*... STILL MORE TO GO

YOU'LL FIND YOUR BIT SIZE IN THIS CHART

SHOULDER DRIVE	BOTTOM DRIVE	TAPER SOCKET
1½"		1¼"
1⅝"		1⅜"
1¾"		1½"
1⅞"		1⅝"
2"		
2⅛"	2½"	Note: Shaded areas are X-Type, others are Cross Type
2¼"	2¾"	
2⅜"	3"	
2½"	3¼"	
2¾"	3½"	
3"	4"	
3½"	4½"	
4"	5"	
4½"	5½"	
	6"	

WRITE FOR FREE BULLETIN 172-7

Drilling Rock with a scleroscope hardness of 90-100 takes a lot out of most carbide bits . . . on this job, other bits were averaging 532 feet. Our illustration shows a Joy bit before and after drilling almost 800 feet in this formation. The average for Joy bits on the entire job was 781 feet.

Here's why: OFFSET WINGS allow drag-free rotation, faster removal of cuttings, easy reconditioning . . . DEEP SLOTTED CHIP WAYS allow cuttings to escape; bit does not regrind its own cuttings . . . INSERT STAYS IN because of new brazing method . . . SPECIAL ALLOY STEEL BODIES heat treated for shock resistance and high fatigue life . . . PRECISION MILLED THREADS instead of tapped threads.

These are the reasons why Joy tungsten carbide bits give extra footage . . . and only Joy bits have all these features. Let your Joy representative prove it to you. ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

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Portable Air Compressors


Wagon Drills


Drilling Bits


Hand-Held Rock Drills

230 horsepower—more than 11.5 available horsepower for every payload ton.

90-degree turns—you save an average of 15 seconds per cycle when spotting under shovels or backing up to hoppers.

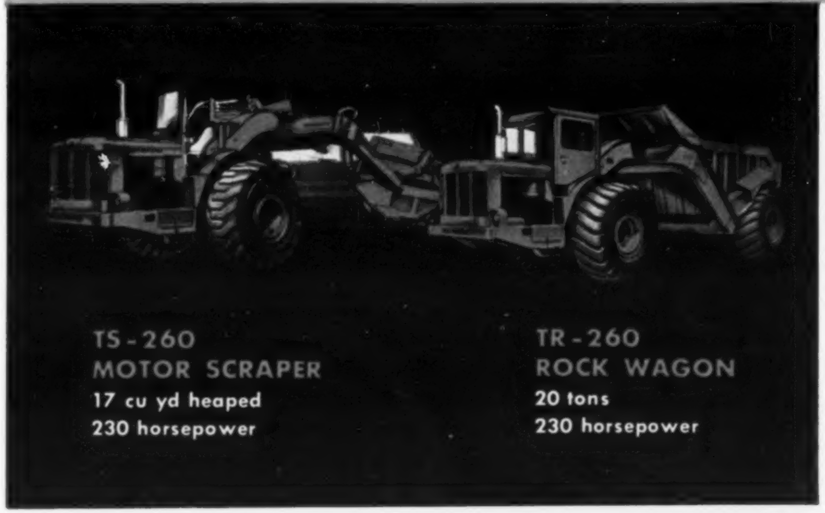
U turns in only 24 ft, 4 in.—you require 20 to 50 percent less turning space than wagons of comparable size.

High ground clearance—with 25¾-in. wagon clearance, the R-260 rolls over high spots. No hang-up problems.

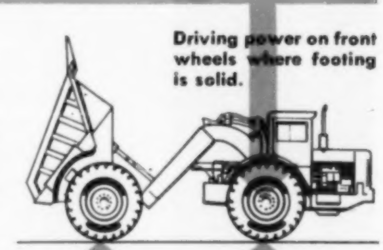
Five speeds to 28 mph—you shift quicker, easier with constant mesh transmission and new actuated transmission brake . . . no double clutching.

Bigger tires—26.5 x 25 low-pressure tires swallow humps and holes with less chance of damage to themselves . . . far less shock to the entire unit. Better traction and flotation, too.

68-degree dumping angle—material rolls out of the clean, unobstructed bowl in a hurry.



Fixed wheel base—solid as a rock . . . and safe . . . The TR-260 dumps with all four wheels braked . . . no need to back up tractor to get loads out. And on the getaway, power is on the forward wheels where footing is solid. No bog-down on embankment lip.



Interchangeability for added earnings . . . The T-260 tractor hauls either the R-260 wagon or S-260 scraper interchangeably. Use the TR-260 for off-the-road hauling—then switch to the TS-260 for stripping or contract earth moving. Earnings are increased . . . you get 100 percent tractor efficiency and reduce equipment investment at the same time. *Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.*

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Mineral Information

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BOOKS

Order directly from the publisher all books listed below except those marked • • • The books so marked (• • •) can be purchased through AIME, usually at a discount. Address Irene K. Sharp, AIME Book Dept., 29 W. 39 St., New York 18, N. Y.

Separation and Purification of Materials, Vol. I in the series **Physical Processes in the Chemical Industry,** by Rolt Hammond (British Author), *Philosophical Library*, 15 E. 40th St., New York 16, N. Y., 327 pp., $10.00, 1958.—This and other volumes of the series are valuable textbooks for chemical engineering students, including basic information and reference material. This volume covers solid-solid, solid-liquid, solid-gas systems plus nuclear engineering and descriptions of the main types of plant and equipment. • • •

Dispersion of Materials, Vol. II in the series **Physical Processes in the Chemical Industry,** by Rolt Hammond (British Author), *Philosophical Library*, 15 E. 40th St., New York 16, N. Y., 230 pp., $10.00.—In this volume there are two thorough chapters on the principles and practice of crushing, grinding, and classifying materials. Other subjects are fluidization, flotation, and liquid dispersions. • • •

United Nations Energy Development in Latin America, *Columbia University Press*, 2960 Broadway, New York 27, N. Y., 274 pp., $2.50, 1957.—A report of a study prepared by the secretariat of the Economic Commission for Latin America of the UN Dept. of Economic and Social Affairs which covers historical background, recent developments, problems, projected future, and suggestions relating to the need for and consumption of energy in Latin America. • • •

The Science of High Explosives, by Melvin A. Cook, *Reinhold Publishing Corp.*, 456 pp., $22.50, 1958.—A theoretical interpretation dealing with fundamentals of detonation processes. Up-to-date information includes research and critical discussion of initiation, wave structure, propagation, chemical reactions, ionization, radiations, shock and blast waves, and damage resulting from detonation. Facts for technological applications include commercial blasting, demolition, and conditions for explosion of materials. • • •

How to Become a Professional Engineer, by John Constance, *McGraw-Hill Book Co. Inc.*, 288 pp., $5.50, 1958.—A clear guidebook for unlicensed engineers-in-practice and graduating students describing the seven basic requirements, state registration laws, and examples of how examination boards evaluate experience. • • •

Daylight Through the Mountains, by Frank Walker, *Engineering Inst. of Canada*, distributed by Sir Isaac Pitman & Sons Ltd., Montreal, Que., Canada, 456 pp., $6.00, 1957.—The life and letters of Walter and Francis Shanly form the story of civil engineers in Canada in the 1850's when many *firsts* marked the progress of Canada's early development. The book describes the first time that electric detonators were used, the first time compressed air was used instead of steam in the rock drills, and the first camp a contractor built for his men so that they had houses, churches, stores, and schools. • • •

The Merrill Story, by David W. Ryder, *The Merrill Co.*, 582 Market St., San Francisco, Calif., 162 pp., 1958.—A commemorative record of the professional achievements and public service of Charles Washington Merrill in his role as an internationally renowned metallurgical engineer and inventor, and of the company that he founded. Requests for copies should be sent to The Merrill Co.

The Problem of Sampling Mineral Deposits, by Filippo Falini, mimeographed booklet, 62 pp., limited copies available from the *author*, c/o Centro Di Studio Di Geologia Tecnica, Universita Di Roma, Rome, Italy. If there are not enough copies

INDEX

BOOKS

(Continued from page 7)

available, photostatic reprints will be sent at cost. 1956.—This paper discusses the fundamentals for the rational planning of a sampling campaign and for the correct interpretation of the results. Sampling is considered only in its most restricted and common meaning as a means for the evaluation of a mineral deposit, provided that the tonnage, shape, orientation, etc. can be considered as already and independently known or obtainable.

Advances in Geophysics, Vol. IV, *Academic Press,* 111 Fifth Ave., New York 3, N. Y., 338 pp., $12.00, 1958.—This volume continues the series and devotes equal space to atmospheric chemistry; theories of the aurora; the effects of meteorites upon the earth; smoothing and filtering of time series and space fields; and earth tides. Reference lists accompany each paper and the volume is indexed by authors and subjects. • • •

Modern Chemical Processes, Vol. V, by the editors of Industrial & Engineering Chemistry, *Reinhold Publishing Corp.,* $5, 1958.—A series of articles describing chemical manufacturing plants, with 14 recently developed chemical processes now in operation, such as elemental phosphorus; electric furnace production; uranium recovery from wet process phosphoric acid; and sulfuric acid from anhydrite. • • •

Drawing For Good Reproduction, by Arthur H. Rau, *National Assn. of Blueprint and Diazotype Coaters,* 1757 K St., N.W., Washington 6, D. C., 32 pp., $1, 1958.—Emphasis throughout the industry on means of improving the copying of engineering drawings has prompted this publication which suggests techniques for mechanical drawing classes and reproduction departments.

A Vision of Steel, by Paquita Mawson, published by *F. W. Cheshire,* Melbourne, Australia, and *Angus & Robertson Ltd.,* 105 Great Russell St., W.C.1, England, 286 pp., approx. $6, 1958.—The life of G. D. Delprat, general manager for over 20 years of the Broken Hill Proprietary Co. Ltd., written by his daughter, which illustrates the pageant of people and events of Australia's history, as well as the progress of steel.

Saudi Arabia, by K. S. Twitchell, *Princeton University Press,* Princeton, N. J., 296 pp., $5, 1958.—Mr. Twitchell is an American mining engineer who formed the Saudi Arabian Mining Syndicate Ltd. and was its consultant until it was liquidated in 1954. He was a personal friend of the late King Ibn Saud and was instrumental in the formation of Aramco. This new edition brings the accepted standard work of the country up to date. • • •

Lehrbuch Der Bergbaukunde, Vol. 2, eighth and ninth edition, by F. Heise and G. Herbst, published by *Springer-Verlag,* Berlin, Germany, 611 pp., approx. $8.15 (34.50 DM), 1958.—Practical detail and fundamental theory of underground mining for coal, ores, and potash are handled in terms of methods of working and exploratory operations, etc. • • •

Estimating Construction Costs, by R. L. Peurifoy, second edition, *McGraw-Hill Book Co. Inc.,* 446 pp., $10.75, 1958.—A practical text outlining various methods of preparing estimates, including new information on bonds, insurance, and depreciation of equipment and cost data brought up to date. • • •

Technical Editing, by B. H. Weil, *Reinhold Publishing Corp.,* 278 pp., $5.75, 1958.—This presents the basic concepts and practices of internal communications, journal editing, book publishing, and graphic arts as related to the technical field. • • •

The Chronicle of United Nations, Document Service, *Hasid-Publishing Co. Inc.,* 234 W. 26th St., New York 1, N. Y., list gratis, 1958.—A list of scientific papers given at the Second United Nations International Conference on the Peaceful Uses of Atomic Energy. Among topics listed are the geology of the Ross-Adam Uranium-Thorium Mine, Alaska, and other U-V deposits. Eight-page title list is free upon request.

Geology and Ores of the Boliden Deposit, Sweden, by Olof H. Odman, *Geological Survey of Sweden,* P. A. Norstedt & Soner, Stockholm, Sweden, 190 pp., 1941.—This description of the geology of the Boliden Deposit was originally intended to be a company report on the investigations the author carried out as a mining geologist of the Boliden Mining Co. during the years 1935-1940. The company helped the author to publish the report and to give it the shape of a detailed geological description.

A Growth Survey of the Atomic Industry, by Frederick H. Warren and others, *Atomic Industrial Forum Inc.,* 3 E. 54th St., New York 22, N. Y., 84 pp., $25, 1958.—The business potentials of the nuclear industry based on the experience of large commercial power plants, with consideration of the nuclear development in Europe, are examined. • • •

Royal Society, London: Proceedings, reprints, Series A, Vols. 169-190, *Walter J. Johnson Inc.,* 111 Fifth Ave., New York 3, N. Y., 4 parts per vol., $22 per vol., $5.50 per part, subscription price for 10 vols. or 40 parts $19.50 per vol., 1958.

Plant Engineering Practice, *F. W. Dodge Corp.,* 119 W. 40th St., New York 18, N. Y., 704 pp., $18.50, 1958.—A handbook covering every major area of plant engineering activity, and consisting of material gathered and prepared by the editors of *Plant Engineering* magazine. It is practical rather than theoretical, its purpose being to offer tested solutions to the many daily problems that the plant engineer and his staff encounter. There are 226 detailed studies organized into 13 sections covering such topics as sites and layout, paints and protective coverings, and housekeeping and safety. • • •

Proceedings of the Third EUSEC Conference on Engineering Education, *The Institution of Mechanical Engineers,* 1 Birdcage Walk, Westminster, London S. W. 1, England, approx. $3.60 to members of participating societies, approx. $4.30 to nonmembers, 1958.—This publication covers the proceedings of the Conference held in Paris in September 1957, with separate appendixes for the United States, the United Kingdom, and Belgian contributions to the conference.

Earth for the Layman, Report No. 2, second edition, by Mark W. Pangborn, Jr., *American Geological Institute,* 2101 Constitution Ave., N. W., Washington 25, D. C., 72 pp., $1.00, 1957.—A selected annotated bibliography of nearly 1400 books and pamphlets of popular interest on geology, mining, oil, maps, and related subjects. This report is designed to give practical assistance to the amateur earth scientist rather than to the professional geologist. For the student of geology and the professional geologist, the bibliography may serve as a convenient source of references, particularly to literature pertaining to the history of geology and early geologists. • • •

Mining Round the World, by June Metcalfe, *Oxford University Press,* 114 Fifth Ave., New York 11, N. Y., 123 pp., $2.50, 1956.—A record of the struggles and achievements of miners and mining engineers. The author gives an account of the mining methods first used and how they have been employed up to the present, and in addition she examines the nature and contemporary role of such key minerals as uranium, tin, copper, lead, silver, zinc, diamonds, and gold. • • •

STATE PUBLICATIONS

Colorado

Geologic Map of anorthosite areas southern part of Laramie Range, Wyoming, Mineral Investigations Field Studies Map MF 119, *U. S. Geological Survey*, Map Distribution Office, Federal Center, Denver, Colo., 50¢, 1957.

Geology of the Du Noir Area, Fremont County, Wyoming, USGS Professional Paper 294-E, *U. S. Geological Survey*, Map Distribution Office, Federal Center, Denver, Colo., $1.25, 1957.

North Dakota

The Geology of North Dakota, J. L. Hainer, Bulletin 31, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 2 maps, 75¢, 1956.

Geology of the North Unit Theodore Roosevelt Memorial Park, by W. M. Laird, Bulletin 32, *North Dakota Geological Survey*, State Geologist, Grand Forks, N. D., 35¢, 1956.

Ohio

The Story of Ohio's Mineral Resources, Information Circular 9, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 14 pp., 1957.

Clay Mineralogy Techniques, by M. F. Aukland, IC 20, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 31 pp., 1956.

Geological Investigations in Ohio, 1956, by Caroyln Farnsworth, IC 21, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 33 pp., 1957.

Lightweight Aggregates in Ohio, Ohio Chamber of Commerce Information No. 17, *Div. of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 7 pp., maps, gratis, 1956.

Uranium, Ohio Chamber of Commerce Information No. 18, *Division of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 10 pp., map, gratis, 1956.

Fluxstone, Ohio Chamber of Commerce Information No. 19, *Div. of Geological Survey*, Dept. of Natural Resources, Orton Hall, Ohio State University, Columbus 10, Ohio, 5 pp., map, gratis, 1957.

Oklahoma

Oklahoma Geology Notes, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., monthly periodical, subscription $2 per year.

49th Annual Report of Mines and Mining of Oklahoma, *Dept. of Chief Mine Inspector*, John M. Malloy, Box 3096, Capitol Station, Oklahoma City, Okla., 1957.

Geology and Mineral Resources of Seminole County, Oklahoma, by W. F. Tanner, Bulletin 74, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 170 pp., 9 plates, 20 figs., $4.75 bound, $4.00 paper, 1956.

Ostracoda of the Simpson Group, by R. W. Harris, Bulletin 75, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 333 pp., 19 figs., 10 plates, 5 charts, $3.50 cloth bound, $3 paper, 1957.

Igneous Geology of the Lake Altus Area, by C. A. Merritt, Bulletin 76, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., $2, 1957.

Microfossils of the Croweburg Coal in Oklahoma, by L. R. Wilson and W. S. Hoffmeister, Circular 32, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 57 pp., 5 plates, $1.75 cloth bound, $1.27 paper, 1956.

Geology of the core of the Ouachita Mountains of Oklahoma, by W. D. Pitt, Circular 34, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 34 pp., 15 figs., colored geological map, $2 cloth bound, $1.50 paper, 1956.

Catalog of Fossils from the Hunton Group, Oklahoma, by T. W. Amsden, Circular 38, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 63 pp., $1.25 cloth bound, 75¢ paper, 1956.

Chester Foraminifera and Ostracoda from the Ringwood Pool of Oklahoma, by R. W. Harris, Circular 39, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 41 pp., 4 plates, $1.50 cloth bound, $1 paper, 1956.

Geology of Northeastern Osage County, Oklahoma, by W. F. Tanner, Circular 40, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla, $2.25 cloth bound, $1.50 paper, 1956.

Two Measured Sections of Jackfork Group in Southeastern Oklahoma, by L. M. Cline and Frank Moretti, Circular 41, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 20 pp., 35¢, 1956.

Geology and Gypsum Resources of the Carter Area, Oklahoma, by George L. Scott, Jr. and William E. Ham, Circular 42, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., $2.75 cloth, $2.25 paper, 1957.

Catalog of Middle and Upper Ordovician Fossils, by Thomas W. Amsden, Circular 43, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 41 pp., $1.25 cloth, 75¢ paper, 1957.

Stratigraphy and Paleontology of the Hunton Group in the Arbuckle Mountain Region: Part I—Introduction to the Stratigraphy, Circular 44, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., $1.50 cloth, $1 paper, 1957.

A Pliocene Vertebrate Fauna from Ellis County, Oklahoma, Circular 45, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., $1 cloth, 50¢ paper, 1957.

Asphaltite in the Ouachita Mountains of Southeastern Oklahoma, by William E. Ham, Mineral Report 30, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 12 pp., map, 25¢, 1956.

The Mineral Industries of Oklahoma in 1955 and 1956, by Peter Grandone and William E. Ham, Mineral Report 32, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 13 pp., 25¢, 1957.

Uranium-Bearing Carbonaceous Nodules of Southwestern Oklahoma, by James W. Hill, Mineral Report 33, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 6 pp., map, 35¢, 1957.

Geology along the Turner Turnpike, Guide Book IV, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., road log and strip map, profiles, historic sites, $2, 1956.

Field Conference on Geology of the Wichita Mountain Region, by William E. Ham, C. A. Merritt, and E. A. Frederickson, Guide Book V, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 58 pp., 1 tab., 1 map, 14 figs., $3, 1957.

Subsurface-Stratigraphic Names of Oklahoma, by Louise Jordan, Guide Book VI, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., $3, 1957.

Tectonic Map of Oklahoma, by J. Kasper Arbenz, Map GM-3, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 50¢ folded, 75¢ in tube, 1956.

Geologic Map of the Criner Hills Area, by E. A. Frederickson, Map GM-4, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 75¢, 1957.

Geologic Map of Northeastern Osage County, by W. F. Tanner, Map A-3, Plate I of Circular 40, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., 60¢, 1956.

Geologic Map of the Carter Area, by G. L. Scott, Jr., Map A-4, Plate I of Circular 42, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., $1.25, 1957.

Geologic Map of the Lake Altus Area, by C. A. Merritt, Map A-5, *Oklahoma Geological Survey*, University of Oklahoma, Norman, Okla., $1, 1957.

Oregon

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ABSTRACTS

In This Issue: *The following abstracts of papers in this issue are reproduced for the convenience of members who wish to maintain a reference card file and for the use of librarians and abstracting services. At the end of each abstract is given the proper permanent reference to the paper for bibliography purposes.*

Trends in Earnings of Engineers, 1956 to 1958 by *Engineers Joint Council*—A brief on conclusions of the 1958 study, *Professional Income of Engineers*, by Engineers Joint Council. Earnings of engineers in the period 1956 to 1958 continued the upward trend observed in the previous survey interval, 1953 to 1956. The overall median (all graduates) was $6500 in 1953, $7750 in 1956 (a 19 pct upstep or about 6.5 pct annually), and $8750 in 1958 (up 13 pct from 1956 or 6.5 pct average yearly). **Ref.: MINING ENGINEERING, January 1959, p. 47.**

Developments in Core-Drilling Techniques For Deep Minerals Exploration by *John K. Hayes and Vernon Read*— Surface and near-surface drilling targets have received most attention from geologists and geophysicists in past years. Now the trend is toward deeper

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exploration holes, and that trend should continue, if not accelerate, in the foreseeable future. Progress in geophysical research makes available the necessary equipment and techniques. Generally speaking, drilling equipment and techniques presently in use are not capable of meeting the complex technical—and economic—requirements of deep core drilling. Drilling to great depths involves increasing risk, time, and money. It is especially true that costs increase with depth when conventional core drilling methods are used. **Ref.: MINING ENGINEERING, January 1959, p. 49.**

Asbestos Production Underway at Black Lake—Lake Asbestos of Quebec's recently-dedicated mining and milling operation has begun output from a lake-bottom deposit that was uncovered only after 55 billion gal of water were pumped off and 27 million cu yd of mud and silt were removed. Open pit work alone is expected to yield 100,000 tons annually for 20 years. Mining and marketing are covered in the discussion, and milling operations are included. **Ref.: MINING ENGINEERING, January 1959, p. 55.**

The Case of the Elusive Orebody by *A. J. Nicol*—In all rotary-drilled holes an interplay of forces affects the direction of bit travel. Discussed are factors affecting the course of the drill steel and use of instruments to determine the extent of borehole drift. Typical drift survey data are included in illustrations. **Ref.: MINING ENGINEERING, January 1959, p. 58.**

TN: Apparatus for Testing Coal Sedimentation by *Shiou-Chuan Sun* (TN 461H)—Most previous work on sedimentation of coal and mineral suspensions has been conducted in graduated 1-litter glass cylinders of 6-cm diam. With this type of large container it is often difficult to see through the suspension and tedious to perform a large number of tests. Furthermore, the heavy glass walls and the graduation lines of glass cylinders cause internal and stray reflections, respectively. To obviate these difficulties, an Atlab Emulsion Viewer from Arthur H. Thomas Co. was adopted as an alternative apparatus. **Ref.: (MINING ENGINEERING, January 1959) AIME Trans., 1959, vol. 214, p. 76.**

TN: Beneficiation of Autunitic Ores by *William C. Aitkenhead and John A. Jaekel* (TN 463B)—An excellent collector for the mineral autunite has been found. The use of the stearic acid-kerosene emulsion has not been investigated as a collector for other uranium minerals more common than autunite. So far there have been no studies of concentrate cleaning and recirculation of the cleaner tailings, which should give a higher grade concentrate with little or no sacrifice of recovery. **Ref.: (MINING ENGINEERING, January 1959) AIME Trans., 1959, vol. 214, p. 66.**

Fundamental Studies of Percussion Drilling by *Howard L. Hartman* (TP 4785A)—Some of the basic concepts of penetrating rock by impact are outlined, including the mechanism of rock failure, steps in crater formation, blow dynamics, and blow indexing. A mathematical analysis of the effect of blow energy on crater dimensions is conducted for various bit shapes. Formulas to calculate rate of penetration in percussion drilling are summarized. **Ref.: (MINING ENGINEERING, January 1959) AIME Trans., 1959, vol. 214, p. 68.**

Polyacrylamide For the Mining Industry by *Merrill F. McCarty* and *Robert S. Olson* (TP 4775B)—Polyacrylamides have been widely used in the mining industry since introduction in 1954. This type of flocculant is used to improve thickening, filtration, and clarification. The increase in operating capacity of liquid-solids separation equipment obtained through the use of this material is having a pronounced effect on equipment and mill design. The characteristics suggest unique application and handling methods in the plant and require the use of modified test procedures in the laboratory. The addition in increments as a dilute solution to a pulp results in optimum flocculation. Optimum use, however, sets other limits. The classic thickening and filtration test methods lead to erroneous conclusions in many instances. **Ref.: (MINING ENGINEERING, January 1959) AIME Trans., 1959, vol. 214, p. 61.**

SME Meeting Papers: *The following abstracts of papers presented at SME meetings are given for your information. Copies of these papers are available only if followed by a preprint order number. These preprints are obtained on a coupon basis. The coupon books may be purchased from SME headquarters for $5.00 a book (10 coupons) for members of AIME or $10.00 a book for nonmembers. Each coupon, properly filled out, entitles the purchaser to one preprint. Mail completed coupons to Preprints, Society of Mining Engineers, 29 W. 39th St., New York 18, N. Y.*

Guides To Ore In The Northwestern Illinois Zinc-Lead District *James C. Bradbury*—Targets for exploration drilling include synclinal structures, areas of rock alteration, and halos of mineralization. Synclines of small amplitude contain belts of mineralization, possibly because more intensive fracturing took place in the synclines than in inter-synclinal areas and gave rise to favored channelways for the mineralizing solutions. In areas of rock alteration, dolomitization and solution of carbonates have been the chief processes. Solution has caused thinning of strata, chiefly in the Decorah and Platteville formations, resulting in sagging or overlying strata and development of "flat and pitch" structures. Halos of mineralization may greatly enlarge the target area and are believed to be the result of migration of solutions along fractures leading from the ore receptacle rather than of a general "soaking" of the host rock. Geochemical and geophysical exploration techniques have had only limited success in the district. *Mid-America Minerals Conference, October 1958.*

Sedimentary Breccias in Southeast Missouri Lead Mines *F. G. Snyder and J. W. Odell*—Large brecciated masses of shaley limestone formed as submarine slides constitute one of the numerous types of ore-controlling structures in this district. These breccias occur especially around high ocean bottom areas formed usually of coarser calcareous sands, and on the borders of neighboring basin structures. The oversteepened slopes between these contrasting areas favored the development of slide masses which moved downhill gouging into the underlying beds and underthrusting and crumpling shaley beds in their path. Often several successive slides were formed, some slicing off the tops of earlier ones. In favorable mineralized areas, these breccias became hosts for important orebodies. *Mid-America Minerals Conference, October 1958.*

Some Performance Parameters of AN-Fuel Oil Explosives *George B. Clark*—Some of the factors which govern performance of ammonium nitrate fuel oil explosion (oxygen balance, composition, grain size, detonation state parameters, explosion state parameters, heat of explosion and available work) are discussed on a quantitative basis employing fundamentals of the hydrodynamic theory, thermochemistry and thermodynamics. Test results and their correlation with fundamental theory bear out the reliability of the Cook method analysis. *Mid-America Minerals Conference, October 1958.*

The Use of Ammonium Nitrate as an Explosive *Dort F. Tikker*—A totally different manner of using ammonium nitrate as a high explosive is now being practiced. When fuel oil (approximately 5 pct wt) is mixed with ammonium nitrate, the decomposition reaction is changed. The fuel oil is apparently in such intimate physical contact with the decomposing and reacting ammonium nitrate that it enters into the primary or first decomposition reaction. *Mid-America Minerals Conference, October 1958.*

A Case History in Pillar Recovery *John J. Reed*—In the older areas of the St. Joseph Lead Co.'s mines in southeast Missouri, the pillars which have been left during almost 100 years of mining now represent the most attractive ore reserve available.

In the case discussed, 26 pillars were proposed for removal. Roof bolting with an especially modified jumbo was used to secure the roof over what were abnormally long spans after pillar removal. Precise convergence measurements, microseismic records and a "convergence warning lamp" were the most useful research tools which supplied quantitative data to increase the safety of the operation. Results to date indicate that mechanized systematic bolting is practical, and where applied in limited areas of high grade pillars, it can permit the recovery of the lead in those pillars at a cost competitive with mining the virgin ore now available. *Mid-America Minerals Conference, October 1958.*

The Piokee Project—An Experiment In Mining Efficiency *Joseph B. Elizondo*—In 1957, Eagle-Picher Co. management attempted to determine how mining efficiency could be increased if most of the key factors governing optimum operating conditions were stipulated. The Piokee Project entailed a given block of low grade ore mined on a carefully controlled basis utilizing the most suitable equipment and facilities available. Results obtained were startling compared with previous standards and have since resulted in a general review of mining practices. *Mid-America Minerals Conference, October 1958.*

Blast-Hole at Geco Mines *G. M. T. Marshall*—All mining (3500 tpd) at Geco is by open blast-hole stopes. Stopes are drilled off with carbide bits, 2⅛ in. diam extension steel, and 4 to 4½ in shell feed drills mounted on bars. Vertical rings are drilled off ahead from sublevels spaced 100 to 130 ft apart, with 8-ft spacing on the rings. By using high velocity explosives and mill-second interval ring delay patterns, fragmentation has been good, resulting in high efficiencies in the scrams. Muck is removed by 125 hp scraper hoists, scraping directly to transfer raises. The transfer raise system feeds by gravity to an underground 44 x 60-in. jaw crusher. The ore is conveyed from the crusher to a loading pocket and hoisted 1300 ft to surface in one 18.5-ton bottom dump skip. The hoists are the first all-North American designed and built "Koepe"-type with the cage skip hoists both semi-automatic. By careful planning, the plant to date has been able to achieve a tons per man shift efficiency that is equal, to, or better than, most mine plants of similar capacity. *Mid-America Minerals Conference, October 1958.*

Shaft Sinking and Lining in the Southern Illinois Coal Field *J. W. MacDonald*—Mine development required two shafts, both of oval section within the concrete lining. The 11 x 20 ft skip hoisting shaft is 756 ft deep.

The air, material and escapement shaft provides 19 ft-9 in. by 30 ft dimensions inside of the concrete lining. Sinking subsequent to the smaller hoist shaft afforded advantage of economy from the earlier experience.

Steel forms were used to provide the concrete lining in the second shaft with advantage over wooden forms used earlier. Other changes included sinking tub capacity increase from one to three cubic yards. The permanent hoist and headframe were installed for sinking the second shaft with but minor additions required to the latter.

The detail review of plant, equipment and procedure extends from the accommodations for mechanical loading of muck and shooting patterns required to the record of performance developed. *Mid-America Minerals Conference, October 1958.*

Preparation of Fine Coal *Emery O. Milligan*—The demand for better preparation of fine coal has increased in recent years. The market for 5/16 in. by 0 or 10 mesh by O products demands a low ash dry enough to handle properly, at the same time not dry enough to create a dust problem. Improved methods for dry and wet cleaning are considered. *Mid-America Minerals Conference, October 1958.*

Ventilation Problems in Connection With Continuous Mining Machines *Donald S. Kingery*—Special ventilation studies of a small blower mounted as an integral part of a continuous miner and operated with line brattice are fully discussed. These data illustrate the ventilation requirements for various face methane liberations possibly encountered in gassy coal mines. *Mid-America Minerals Conference, October 1958.*

Fuels Used In Manufacturing *Walter H. Voskuil*—Cost of fuels used in manufacturing according to the 20 groups of industries as classified by the Census are analyzed. Fuel costs of coal, coke, fuel oil, natural and manufactured gas are expressed in cents per million btu's.

Data includes changes in the quantity and cost of each of the fuels from 1947 to 1954 and the percentage increase; ratio of fuel costs to wage costs for 1947 and 1954 together with changes in the ratios; and the number of btu's and kilowatt hours, used per worker in each of the 20 industrial groups. *Mid-America Minerals Conference, October 1958.*

Inventories—Aid and Deterrent to Coal Industry Stability *Hubert E. Risser*—Ceaseless

fluctuations in the demand for coal constitute a major problem of the industry. Recent trends in pattern of coal consumption tend to accentuate rather than decrease the fluctuations.

Twenty-five years ago retail deliveries accounted for 26 pct of total consumption and were reasonably free from extreme or violent fluctuations. Railroad use which accounted for another 21 pct of consumption was also relatively constant. These uses, almost half of total market exerted a stabilizing effect on total production. In 1957, retail and railroad consumption accounted for less than 18 pct.

As the level of coal consumption becomes increasingly tied to industrial markets, the the coal industry can share to a greater degree in general industrial growth. At the same time the effects of future fluctuations in industrial activity will be greater. *Mid-America Minerals Conference, October 1958.*

Barite in Washington County, Missouri, History and Development *Earl L. H. Sackett*—Brief discussion of the geological occurrence of Washington County barite deposits is given. History and technology of barite industry includes description of present day plants as well as flow sheet and material balance of these plants; description of prospecting and development methods; review of the barite production history of Washington County. *Mid-America Minerals Conference, October 1958.*

Undeveloped Industrial Rocks and Minerals of Missouri *T. R. Beveridge*—Some of the industrial rocks and minerals of Missouri which may be of greater economic interest in the future are: glauconite, high-potash feldspar, quartzite, rock wool material, bloating shales, Pennsylvania underclays, high purity dolomites, asphaltic sandstone for foundry purposes, and bleaching clays. Certain gravels, limestones and dolomites which are at present unacceptable for concrete aggregates may be used in the future if specifications can be made more flexible without lowering standards, or if inexpensive methods of beneficiation can be devised. High purity limestones are undeveloped in some parts of the state because of zoning restrictions which force industry to go far afield for additional reserves. *Mid-America Minerals Conference 1958.*

The Utilization of Red Mud Waste from the Aluminum Industry *Nat L. Shepard*—Bauxite refining in the aluminum industry gives from one to three tons of "red mud" for each ton of aluminum produced.

The fine red mud from high-silica Arkansas bauxite is used in a sinter process to recover soda and alumina, and yields a substantially equal tonnage of "sinter mud" which approaches the composition of the raw mix Portland cement and might serve as a raw material for that industry. Red muds from bauxites other than those of Arkansas are not processed through the sinter step.

Titanium minerals occur in Arkansas mud in two generations: (a) discrete grains of manganiferous ilmenite, and (b) dispersed leucoxene. The titanium content of the muds from Suriname and Caribbean bauxites is all in the dispersed form.

Red mud from Arkansas bauxite contains from 0.1 to 0.2% columbium pentoxide which is too finely dispersed to permit mechanical concentration.

Many proposals have been investigated but no large scale use for red mud other than in the sinter process has been developed to date. *Mid-America Minerals Conference, October 1958.*

Light-Weight Aggregate Resources of Illinois *W. Arthur White*—Chemical data were obtained for about 90 samples of shales and clay. It was found that the shales and clays which had a greater ratio of ferrous iron to ferric iron bloated whereas the shales which had a greater ratio of ferric iron to ferrous did not bloat. The clays and shales which had a larger percentage of ferric iron than ferrous were weathered outcrop samples and the ones which had a greater ratio of ferrous than ferric iron came from pits which were being actively mined. This study suggests that if the weathered material is stripped away, most shales will be self-expanding. *Mid-America Minerals Conference, October 1958.*

A Study of Missouri Bloating Clays and a Suggested Mechanism for the Bloating Process *T. J. Planje*—Twelve of 55 samples were bloated at commercially feasible temperatures in oxidizing and reducing atmosphere only. The remaining 33 samples either failed to bloat or the bloating tendency was inadequate to yield a product which would meet current density requirements. The bulk densities of the aggregates produced from the 22 bloated samples are given along with the mechanical properties of concrete specimens that were compounded from several of the aggregates. The mechanism of bloating as related to the chemical properties of the clay materials was investigated, and a generalized relationship between composition and bloating tendency is presented. *Mid-America Minerals Conference, October 1958.*

Developments in Cooperative Zinc Research *D. W. Pettigrew*—The zinc industry, along with the lead industry, recognizes the need for expanded research to expand existing markets and to develop new ones. To this end, a research program is now functioning on the part of the domestic zinc and lead producers and a substantial portion of the foreign producers. *Mid-America Minerals Conference, October 1958.*

Flow of Bulk Solids *Andrew W. Jenike, Philip J. Elsey, and Roscoe H. Wooley*—Recent tests carried out at the Bulk Solids Flow Laboratory of the Utah Engineering Experiment Station, University of Utah have exposed at least one cause of the wide divergence of experience with feeder pressures and with feeder horsepower requirements. Tests show that pressures during continuous flow are lower than had been expected while starting pressures may be very high under adverse bin conditions. Factors contributing to low pressures and uniform flow will be discussed. *Mid-America Minerals Conference, October 1958.*

Geophysical Exploration Techniques *George V. Keller*—During the past few years more new and improved geophysical instruments have been placed on the market. The advances in geophysical instrumentation have been mainly in the fields of magnetic, electromagnetic, and seismic exploration and should aid materially in search for mineral deposits. However, more information is needed on rocks in mining districts and the cause of anomalous conditions. This information will serve as a basis for determining if conventional surface techniques can be used.

A systematic investigation of the physical properties of rocks in situ has been undertaken by the U. S. Geological Survey using in-hole logging techniques and laboratory studies. Most of the work to date has been in the Lake Superior iron ranges and the copper districts of Michigan and Wisconsin. The results indicate that electrical prospecting methods should be used to supplement magnetic and gravimetric surveys in locating taconite deposits; and that the induced polarization technique can be used successfully to locate the copper ore deposits. *Mid-America Minerals Conference, October 1958.*

The Recovery of Metallic Cobalt and Nickel At Fredericktown *W. R. McCormick*—Beginning in 1947 an extensive research program has been carried on with the objective of developing a commercial process for recovery of cobalt and nickel by the National Lead Company and others. The complex nature of the ore and minerals eliminated conventional methods of treatment. In 1953 National Lead Company built a metals refinery in Fredericktown. The refinery incorporated the unique methods previously developed to produce cobalt, nickel and copper metals. In this process the cobalt-nickel containing sulfide concentrate is slurried in water and oxidized to a sulfate by pressure-leaching with air. The residual iron remaining in solution is removed by pH control. Copper is removed from the sulfate solution by reducing with hydrogen. The nickel is separated from the cobalt by oxidizing an ammoniacal solution and precipitating the nickel as nickel-ammonium sulfate with sulfuric acid. The cobalt solution is then reduced by hydrogen, resulting in the production of cobalt metal powder. The nickel salt is put in solution and then reduced by hydrogen, resulting in the production of nickel powder. *Mid-America Minerals Conference, October 1958.*

Mechanical Charging Practices of Horizontal Retort Zinc Smelters in 1958 *B. F. Buff*—Since 1955 the use of machines to charge horizontal retorts has been extended to all of the horizontal retort plants of National Zinc Co. Charts, slides, and tabulations will show savings in labor and changes in recovery. *Mid-America Minerals Conference, October 1958.*

The Changing Pattern of the Iron Industry *Horace T. Reno*—After a half century of relative stability, the pattern of the iron-ore industry now is changing rapidly because the steel industry is spreading out to give more people a higher standard of living and some traditional iron-ore sources are no longer able to supply the demand. World consumption has more than doubled in the last decade, and during that time many small, not heretofore industrial, countries have begun to consume iron ore. From 1950 to 1954 apparent annual world consumption averaged 249 million long tons containing about 107 million tons of iron. European countries, including Russia and its satellites, consumed 60 pct of the total. The United States consumed 135 million tons of iron ore in 1957, an all-time record, but its share of the world total was less than the 1950-1954 average, and preliminary figures indicate that the European share of the total was more than this average.

The pattern of iron-ore production has changed even more than the pattern of consumption. Production, of course, has followed consumption—there are no large stockpiles of iron ore. European resources, except in Sweden, have not completely satisfied requirements; beneficiation has been increasingly applied and imports have supplied a larger percentage of the total. On other continents, some countries that 10 years ago did not produce iron ore now are among the principal producers.

Within the United States, the pattern of iron-ore consumption and production has, to a marked degree, either followed or led the changing world pattern. Primary steel plants have been built on both coasts, greatly broadening the area of domestic consumption. Huge beneficiation plants now permit mining low-grade ores to replace the traditional high-grade ores. Iron-ore imports have increased from a few million tons a year exchanged with Canada to more than a fourth of the total domestic supply. Seven states, that each produced only a few thousand tons of iron ore annually ten years ago, are now each producing more than a million tons a year. Missouri is one of the seven new iron ore producers. *Mid-America Minerals Conference, October 1958.*

Geology and Exploration of Missouri Iron Deposits *William C. Hayes*—Three major iron ore districts of the central states are the residual limonite deposits of the Russeville, Alabama district, the Tertiary limonite deposits of east Texas, and the residual limonite-hematite deposits and Precambrian hydrothermal deposits of southeastern Missouri.

The sedimentary deposits are of two types: residual limonite fragments concentrated in a cherty clay residuum overlying Paleozoic carbonates, and hematite occurring with clay in solution depressions, commonly called "filled sink" deposits.

The ore minerals of the Precambrian deposits that occur as fissure fillings and replacement veins are hematite, magnetite, and martite. Spatial relations of the minerals suggest a zonal arrangement both regionally and in individual deposits. Important gangue minerals are quartz, apatite, fluorite, garnet and amphiboles.

Magnetic and gravimetric anamolies have been drilled disclosing several iron deposits of economic importance. *Mid-America Minerals Conference, October 1958.*

An Effective Drill for Coring Alternating Hard and Soft Material *A. B. Drescher*—In its exploration and mine development drilling Lone Star Steel Co. of Texas deals with some difficult sampling problems with a special drill of its own design. Principal difficulties have to do with alternating hard and soft materials. Securing large samples, about ⅓ cu ft per ft of depth, with a minimum of ore breakage, is necessary to properly represent this type of variable ore. Careful logging of formation for ore zone correlation is also necessary. The principal distinctive features of the drill are its single-piece long kelly, and its dry, rotary coring action. The drill has also proven suitable in construction engineering, particularly in recovering relatively undisturbed core in earth dams and foundations. *Mid-America Minerals Conference, October 1958.*

Underground Mining of Iron Ore at the Ozark Ore Co. *R. P. Matson*—A short history of the mine, a condensed geological explanation, a description of the mining method and equipment in use at the mine, and a short description of the necessary beneficiation required to produce iron ore concentrate are given. *Mid-America Minerals Conference, October 1958.*

Experiments in the Concentration of Iron Ore from the Pea Ridge Deposit, East Central Missouri *M. M. Fine and D. W. Frommer*—Mineral dressing research showed that iron concentrates of commercial quality could be produced from the Pea Ridge deposit near Sullivan, Mo. Magnetic separation and flotation on a laboratory scale yielded concentrates ranging in iron content from 60.0 to 71.4 pct. at recoveries of 89.9 to 97.6 pct. *Mid-America Minerals Conference, October 1958.*

Utilization of the Missouri Iron Ores *Walter J. Deptula, Jr.*—This paper will present, in broad outline, the many problems pertinent to the effective utilization of Missouri iron ores. A brief history of the extent to which Missouri ores have been utilized in the past is included; and many reasons and problems which have hindered complete successful utilization and exploitation of all these ores are described. It is shown that some of these ores must be relegated to specific uses only. Future prospects and problems are discussed. *Mid-America Minerals Conference, October 1958.*

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MEETINGS CALENDAR . . . . Solid dots are AIME Meetings

Jan. 12, AIME Minnesota Section, annual meeting, Minneapolis.

Jan. 13-14, Annual Mining Symposium, University of Minnesota, Center of Continuation Study, Duluth.

Feb. 15-20, AIME Annual Meeting, SME Headquarters: Sheraton-Palace Hotel, San Francisco.

Feb. 23-27, Application of the FluoSolids Reactor to the Mineral Industry, Part I, University of Arizona, Tucson, Ariz.

Mar. 2-3, Application of the FluoSolids Reactor to the Mineral Industry, Part II, University of Arizona, Tucson, Ariz.

Apr. 5-10, EJC Nuclear Science and Engineering Conference. Public Auditorium, Cleveland.

Apr. 6-8, Blast Furnace, Coke Oven & Raw Materials Committee and National Open Hearth Steel Committee Conferences, Hotel Jefferson, St. Louis.

Apr. 13-15, CIM annual meeting, Queen Elizabeth Hotel, Montreal.

Apr. 16-18, AIME Pacific Northwest Regional Conference, Olympic Hotel, Seattle.

Apr. 20-22, Rock Mechanics Third Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; at Colorado School of Mines, Golden, Colo.

May 8-10, Fourth Annual Uranium Symposium, AIME Uranium Section, Moab, Utah.

May 11-14, American Mining Congress, Coal Show, Public Auditorium, Cleveland.

June 15 (approx.), AIME Pittsburgh Section—SME Coal Division, joint meeting, Waynesburg, Pa.

June 28-July 1, Rocky Mountain Coal Mining Inst., annual meeting, Antlers Hotel, Colorado Springs, Colo.

Sep. 14-17, American Mining Congress, Metal Mining & Industrial Minerals Convention, Denver.

Sep. 24-26, SME Coal-Industrial Minerals Divisions, joint meeting, Bedford Springs, Pa.

Oct. 8-10, Exploration Drilling Symposium, tri-sponsors: Colorado School of Mines, Pennsylvania State University, and University of Minnesota; at Pennsylvania State University, University Park, Pa.

Oct. 27-29, AIME-ASME Joint Solid Fuels Conference, Netherland Plaza Hotel, Cincinnati.

Nov. 9-12, Society of Exploration Geophysicists, annual meeting, Biltmore Hotel, Los Angeles.

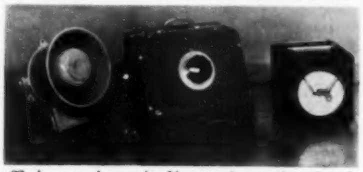
Dec. 7, AIME Arizona Section, annual meeting, Tucson, Ariz.

MANUFACTURERS NEWS

NEWS / EQUIPMENT / CATALOGS

New Grinding Controls

Hardinge Co. Inc. has developed four grinding mill control and observation units employing the Electric Ear principle, but with new sound recording features. Hardinge engineers claim 10 to 20 pct better



efficiency in grinding when the feed control is used. New recording feature indicates: operating and shutdown time; bin condition above feeder, if bridging or empty; setting changes by operator; erratic operation due to feed size change, moisture variation, or lack of attention. Portable model PSR is shown. **Circle No. 1.**

Cat Scraper

Caterpillar Tractor Co. has added another scraper for use with the DW20 wheel tractor, the 24-yd struck capacity No. 482 Series B. The new unit joins the 18-yd No. 456 and is intended for economical application in good loading conditions, where grades are minimum and rolling resistance is low. Optimum sheave and cable life is given by direct attachment of lift cables to bowl sides, an arrangement that protects from dust and fouling. **Circle No. 2.**

AccuRay Level Control

Exacting control of level in industrial tanks and bins is available with the AccuRay level detection-control and continuous level measurement systems by *Industrial Nucleonics Corp.* Components are mounted externally. Maximum safety is provided. **Circle No. 3.**

Titanium Wire Cloth

Screening highly-corrosive pulps will be less trouble when a new titanium wire cloth by *Newark Wire Cloth Co.* is used. Initial production will range from 4 to 120 mesh with wire ranging from .80 to .001 in. diam. **Circle No. 4.**

Mine Trackwork

Bethlehem Steel Co. has available a complete line of mine and industrial track items for rails 20 to 100 lb per yd. Bethlehem will custom-design mine systems and furnish detailed drawings to make future replacements easy. The company offers interested readers its 204-page illustrated catalog, a valuable indexed reference manual. Included is data on mine arches, roof bolts, drill steel, mine cars. **Circle No. 5.**

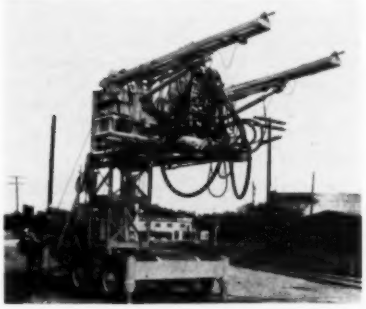
Improved AN Agent

An ammonium nitrate material called N-IV by manufacturer *Spencer Chemical Co.* features superior oil absorption and can be detonated using only ⅜-in. blasting cord. N-IV

is surface coated to eliminate caking and is bagged in waterproof polyethylene. **Circle No. 6.**

Drill Jumbo

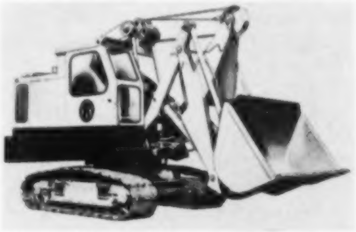
A large salt mine recently started using the *Rogers Iron Works Co.* jumbo shown below. This model VM-212-17 will drill all holes in a 12-ft wide, 20-ft high heading in one spot. Diesel power drives four rear wheels and also a generator which,



in turn, drives an electric pump that supplies hydraulic power. Other models are available for hard rock percussion drilling. **Circle No. 7.**

Skooper

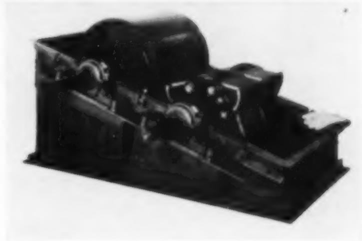
The fast swing of an excavator turntable and a 7-ft independent crowding action are combined in *Koehring's* Skooper for fast loading in quarries, pits, or underground. Available with buckets ranging from



1⅞ to 2½ cu yd, the Skooper has a cutting height of more than 17 ft and has ample clearance for loading trucks, rail cars. **Circle No. 8.**

Rollhammer

A combined roll crusher and hammer mill that is particularly adaptable for materials that tend to build up is offered by *O'Brien Industrial Eqpt. Co.* Hammer and roll are driven independently at different speeds. One 24-in. unit reducing to 6-mesh for six years at 40 tph on super-phosphate has never suffered hammer freeze. **Circle No. 9.**



Big Scraper

Biggest new addition to the *Curtiss-Wright Corp.* line of high speed earthmovers is the two-axle model CW-226 by the company's South Bend Div. Capacity is 26 cu yd struck, 36 yd heaped. GM 375-hp diesel powers through Allison automatic transmission and torque converter. Scraper is interchangeable with a 35-ton rear dump unit. **Circle No. 10.**

(Continued on page 16)

Manufacturers' News

(Continued from page 15)

Sludge Pump

An air-powered sludge pump, which can remove 42 gpm at a 175-ft head is offered by *Thor Power Tool Co.* Motorless pump draws in sediment by suction until tank is filled, then automatically discharges under pressure. The few working parts are stainless and automatically lubricated. **Circle No. 11.**

Diamond Drill

Chicago Pneumatic Tool Co. recommends its husky new CP-65 diamond drill for blast hole, coring, or grout hole work. Throttle is stepless, motor is reversible. Drill mounts

on standard saddle, is only 42½ in. long with built-in swivel head. Ball bearings are used throughout. **Circle No. 12.**

Sizer

The Mogensen sizer by *Machinery Center Inc.* consists of five or six screens mounted in a vibrating frame. It separates sharply as does a single screen, but the sizer has the advantage of higher capacity, no screen blinding, and small screen cloth wear, according to its maker. **Circle No. 13.**

Diaphragm Pumps

Denver Eqpt. Co. adjustable stroke diaphragm pumps are now available in a full range of sizes, from 1-in. simplex to 10-in. duplex, with capacities from 2½ to 1000 gpm. Diaphragm is of patented spiral nylon cord construction, catenary curved to avoid kinking. Heavy molded rim permits clamping and eliminates bolts that would weaken the diaphragm. **Circle No. 14.**

Diesel Crawler

A powerful medium-size crawler tractor has been introduced by the Construction Eqpt. Div. of *International Harvester Co.* The new 105-hp TD-15 features a 6-speed, single stick, full reverse transmission. Shuttle bar control permits instant reverse or forward movement without shifting. **Circle No. 15.**

Car Shaker

Stephens-Adamson Mfg. Co. has announced its Carquake, a hydraulically powered car shaker designed for efficient unloading of hopper-bottom railroad cars. Claimed less noisy and more economical than overhead shakeouts, the Carquake

is offered in two models: stationary type B and rail-mounted type C (shown). **Circle No. 16.**

Motorized Head Pulleys

A self-contained power package for driving belt and bucket conveyors is offered in the Schrock motorized head pulley by *Western Conveyor Co.* Motor, reduction gears, and all moving parts are contained in the pulley shell allowing compactness and decreased weight. Explosion-proof motors are available for dusty or gaseous areas. **Circle No. 17.**

Mine Machine Lubricant

Use just one lubricant at the face says *Gulf Oil Corp.*, maker of new lubricant H. D. Intended specifically for mine machines, the new product is a multi-purpose, semi-fluid grease that resists water, extreme pressures, and high temperature. Except for hydraulic system oil, H. D. fills all grease needs at the mine face. It can be poured or pressure gunned. **Circle No. 18.**

Extraction Plant

The Spiradyne column extraction plant by *Podbielniak Inc.* is a packaged assembly designed for pilot plant use or for small scale production. Plant consists of a gravity column with impeller mixing sections for intimate contacting of two phases. Sections are assembled on a rotating shaft controlled by a variable speed drive. Spiradyne unit is available in capacities ranging from 20 cu cm per min to 20 gpm. **Circle No. 19.**

Exhaust Gas Conditioner

A new exhaust gas conditioner which allows diesel-powered equipment to operate underground is offered by *National Mine Service Co.* Unit cools exhaust gases from as high as 1300°F to a maximum of 160°F and removes solid combustion products which normally appear as smoke. The water-batch uses no chemicals, operates on a venturi-pressure principle. **Circle No. 20.**

Surface Binder

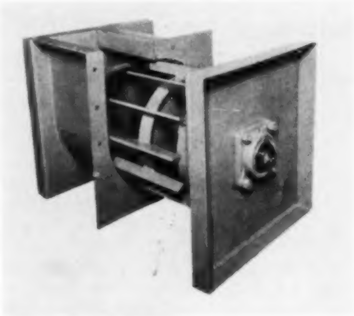
Aerospray 52 binder by *American Cyanamid Co.* prevents costly losses of fine coal, minerals when it is sprayed on exposed surfaces laying in open storage or rail cars. Crust formed is insoluble in water. **Circle No. 61.**

Transistorized Seismograph

Texas Instruments Inc. makes available a new seismic amplifier system called the Explorer, model 8000—a 24-channel portable unit weighing only 57 lb. Power is supplied by another portable case weighing 45 lb. Frequency response range is 5 to 200 cps, with dynamic range of 100 db. Unit draws only 9 amp from the 12-v battery. **Circle No. 62.**

Paddle Feeder

Pulsating material delivery is eliminated by a newly-designed rotary paddle feeder which delivers a constant, uniform stream. Design prevents material pile-up and is self cleaning. Uninterrupted flow is assured by regulating baffle at discharge point. Unit is by *Richardson Scale Co.* **Circle No. 63.**



Shrouded Block

Sauerman Bros. now makes its Durolite blocks available with shrouded housings to insure proper seating of running rope. Shrouds are particularly recommended where blocks must operate on horizontal plane and rope tends to leave the sheave grooves. **Circle No. 64.**

NEW DW20
Series G

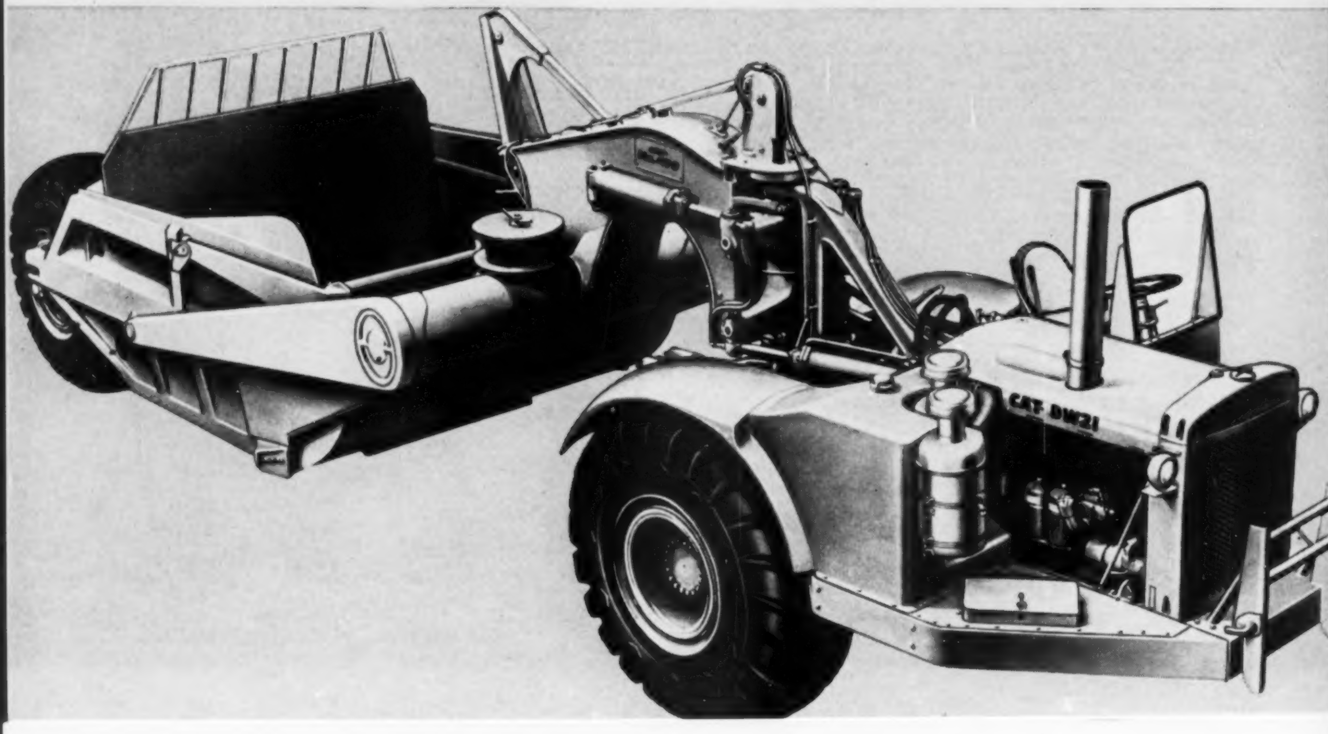
NEW No. 456
Series B

NEW HP —345 (maximum output)—increased 8%
NEW RIMPULL —39,565 lb. (maximum)—increased 12%
NEW SPEEDS —increased rimpull—provides up to 20% faster travel speeds under normal haul road conditions
NEW CAPACITY—19.5 cu. yd. (struck)—increased 8%
27 cu. yd. (heaped)—increased 8%

NEW DW21
Series G

NEW No. 470
Series B

NEW HP —345 (maximum output)—increased 8%
NEW RIMPULL —49,100 lb. (maximum)—increased 12%
NEW SPEEDS —increased rimpull—provides up to 20% faster travel speeds under normal haul road conditions
NEW CAPACITY—19.5 cu. yd. (struck)—increased 8%
27 cu. yd. (heaped)—increased 8%



CATERPILLAR'S PROJECT PAYDIRT

PROJECT PAYDIRT pays off for you*

NEW CAT DW20 and DW21 SERIES G TRACTORS NOW 345 HP

—plus new high-capacity LOWBOWL Scrapers for faster cycles and higher production!

For down-to-earth facts about these big new Caterpillar rigs, take a look at the box scores shown here. They summarize important increases in horsepower, rimpull, speeds, scraper ratings and tire capacities that pay off for you *on the job* with faster cycles, greater production and more profit!

Note that the increased HP of the DW20 and DW21 Series G, compared with the models they're replacing, gives 12% higher rimpull. This increased rimpull provides up to 20% faster travel speeds under similar haul road conditions. Equally important, this horsepower increase was achieved without any sacrifice whatsoever in the excellent torque characteristics inherent in the Cat Super-Turbo Engine. Torque rise of the engine in the Series G models is unequaled in the earthmoving industry.

In addition to the advantages featured in the box scores, the new Series G Tractors and their matching LOWBOWL Scrapers deliver the *proved* reliability of Caterpillar-built machines. To handle increased horsepower and increased capacity, both have been improved in design and structure. The tractors, for example, have stronger final drive gears and improved transmission shifter forks. The scrapers have stronger bowls, push frames, draft frames and aprons. All these and other improvements result in better service life, less maintenance and lower cost dirt.

Here are modern, heavy-duty wheel rigs geared to the needs of today's highly competitive market—rigs that meet your requirements for moving more dirt at lower cost than ever. Get the complete facts about them from your Caterpillar Dealer. Call him today and set a date for a demonstration!

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

BORN OF RESEARCH
PROVED IN THE FIELD

TIRES: 29.5-29 (28-ply rating) are now standard in place of the former 29.5-29 (22-ply rating) — a tire capacity increase of 16% to match the increased scraper capacity, heavier machine weight and higher speeds made possible by more HP. Note: On the DW20 Series G, the front tires remain the same — 14.00-24 (16-ply rating).

CATERPILLAR'S PROJECT PAYDIRT

***PROJECT PAYDIRT:** Caterpillar's multi-million-dollar research and development program — to meet the challenge of the greatest construction era in history with the highest production earth-moving machines ever developed.

1958 has been a year of healthy consolidation. The generally lower level of new business we have had in common with most capital goods companies has given us a much needed opportunity to examine all our operations with the emphasis on sharpening efficiencies and stepping up the rate of our technological advance. In both, we have made substantial gains.

The sharpening of efficiencies is evidenced by a number of changes. Our manufacturing costs and delivery times are both noticeably better. A reorganization of our Research & Development group has resulted in a greater emphasis on basic research and a speeding up of development of new processes and equipment. This will ultimately include more and better manpower in both these areas. We have simplified routines, eliminated many nonessential operations and projects which seem to creep in during boom times. This allows us to proceed with less staff, but a more able and experienced one.

The current lag in new business has been much less noticeable overseas, and we have been concerned with a number of very large and significant projects abroad. Our subsidiaries have continued to progress and are contributing substantially to the financial balance of our consolidated effort.

PLANT ENGINEERING — The year's major project was the design of a 150 metric ton per day triple superphosphate plant for Mexico. This large contract includes process engineering, plant design, purchase of equipment and supervision of construction of the granular fertilizer plant as well as attendant facilities such as labs, cafeteria, offices and guest house.

A second substantial current project, which is being carried out jointly by D-O and one of our subsidiary companies in Europe, is the design of a large Yugoslavian copper concentrator. Also engineered abroad were a Belgian dicalcium phosphate plant and the expansion of a German phosphoric acid plant. During the year a large fertilizer installation in England went into operation and was rapidly brought up to operating capacity. A fertilizer plant in Montana and a copper concentrator in Israel, both D-O designed, were put into operation late in the year.

Latest addition to the list of installations which the company can now design is the board plant. We are staffed and equipped to engineer any of the basic types including wet or dry process hardboard and particle, insulating, gypsum and flake board.

PULP AND PAPER — A Canadian pulp producer will install a complete D-O Bleach Plant, and Bleach Washers will be utilized in expansion of an Indian groundwood mill. Late in the year Brownstock Washing and Recausticizing Systems, Deckers and hypochlorite preparation equipment were ordered for a new French mill. At a second French mill, a large Brownstock Washing System was put into operation in 1958.

Recausticizing Systems will be installed at two other new mills, one producing paper in India and the other linerboard in the western United States. Continued evidence of widespread acceptance of the American Disc Filter has been demonstrated by the number of orders entered for this efficient saveall. Also of interest were filters ordered for local manufacture from our Australian subsidiary and our Japanese representative.

FOOD PRODUCTS — In the citrus industry, Merco Centrifuges and Mercone Screening Centrifuges have been applied to the finish-processing of orange juice prior to concentration. Successful also has been application of

the Centrifuge-Precoat Filter combination to apple juice processing.

Corn starch washing systems consisting of various combinations of centrifugal equipment were ordered for mills in the United States, Colombia, Holland and Mexico. And, as in so many previous years, the sale of RapiDorr Clarifiers and O-C Filters for cane sugar processing has contributed heavily to orders entered.

FLUOSOLIDS SYSTEMS — Applications of the FluoSolids system were broadened in 1958 to include heat treatment or drying of such materials as foundry sand, phosphate base food products and concentrated detergent and for carbon reactivation. Another new application will be partial roasting of sulfide concentrates at one of Canada's largest smelters.

Other FluoSolids projects now in the design stage or under construction are slag dryers for India and Alabama; pyrite roasters for Spain, South Africa and California; a coal dryer for a midwestern producer and two-stage arseno pyrite roasters for installation in the gold fields of northern Canada. Now in operation or under construction around the free world are over 100 FluoSolids installations on such proven applications as sulfide ore roasting, coal and slag drying, and limestone and phosphate rock calcination.

SANITATION — This phase of our business has been particularly active during 1958 both at home and abroad. Over thirty-five installations of the CompleTreator sewage treatment unit, first introduced last year, are now in operation providing treatment facilities for housing developments, industrial plants, and other small centers of population. Equipment for large domestic projects now under construction include Clariflocculators for a chemical precipitation plant in northern New York State, Densludge Thickeners for the nation's capitol, large Digesters and Distributors for Dallas County, and Clarifiers and Distributors for a Biofiltration plant in Kansas.

Abroad, D-O will supply units for two plants in New Delhi, as well as for installations in Venezuela, Iraq and Kenya. North of the border, extensive additions to the metropolitan Toronto treatment system will be D-O equipped.

Major developments in this field have been the SR Clarifier, a new rapid sludge removal mechanism for final clarification in biological treatment, and the D-O Aerator for the activated sludge process. Installations using both units are already in operation, and a major pulp and paper producer has ordered Aerators for a new waste treatment plant.

COAL — Fine coal recovery and water clarification will be accomplished at Eastern and Australian cleaning plants in large Thickeners ordered within the past year. In a number of instances, an American Filter and ODS Pump will complete the fines recovery circuit.

IRON AND STEEL — Proof of the versatility of the DSM Screen is its application at three points in the heavy media cyclone flowsheet. In its first use on the Iron Range it has considerably reduced magnetite losses. In this general field also the Thickener-Filter combination has continued to be widely applied to recovery of blast furnace flue dust.

CHEMICAL — In 1958 new developments highlighted Dorr-Oliver activity in the far-flung chemical industry. Among the foremost of these was the plastic Filter, a rotary drum vacuum unit constructed of plastic with glass fiber reinforcing. Initial orders indicate the applicability and economy of this unit for mildly corrosive applications.

A second major development, the Merco H-30 Centrifuge, provides the chemical industry with a high capacity, high speed unit capable of clarifying up to 600 gallons of slurry per minute. The product of nearly four years of testing, this machine has substantially reduced operating power requirements per gallon of feed. One of the first commercial applications will be crystal separation at 90° below zero.

Result of yet another new design program is the expanded line of Type L centrifugal pumps. Here, three new designs provide increased capacity and head range and reverse inlet flow for operating speeds of both 1750 and 3500 rpm. In addition, Hypalon elastomer lining is now standard for both Olivite and ODS Pumps.

During the year a German manufacturer ordered the eighth and ninth Horizontal Filters for dewatering artificial resins, and domestic producers purchased Horizontals for such applications as washing ammonium sulfate and nitrocellulose and filtering potash and copperas. Also in the potash field was use of the DSM Screen for debrining crystallizer underflow.

GENERAL METALLURGICAL — Development of an air-lift agitation system for the American Filter has provided a third method of maintaining heavy solids in suspension prior to filtration. Complementing the conventional paddle and swing agitators, this new method has been extensively tested at operating installations.

U. S. and Chilean producers have ordered giant Thickeners with the strongest turntables ever fabricated, and a copper mill in the Belgian Congo will utilize ten large vacuum Filters in a current expansion. New construction at U. S. cement plants includes the three largest Slurry Mixers ever furnished, each 120 feet in diameter, as well as a variety of smaller machines.

WATER — Here also new construction and plant expansions resulted in application of a variety of D-O pretreatment equipment. Two large Hydro-Treator mechanisms will supplement four additional units already in operation at Miami, Florida; and Topeka, Kansas will utilize Presedimentation Clarifiers and Flocculators. PeriFilter systems will be installed at Peoria, Illinois and Leander, Texas; and in Mexico City the first PeriFilter of a new, simplified control design is now going into operation.

Not the least of our gains in efficiency has resulted from new and vastly improved headquarters facilities both here and abroad. Our new International Headquarters was completed here in Stamford in July, the staff of D-O NV expects to move its own new office building in Amsterdam shortly, and our associates in both Brussels and Paris are enjoying new and excellent facilities in co-operatively owned buildings.

In every respect, we are better prepared than ever before to take advantage of the upswing to come and to give better service to our customers throughout the world. This betterment, of course, could only have come about by the diligent and co-operative efforts of our total staff, and to them belongs the credit for the work done.

J. D. Hitch, Jr.
President

November 5, 1958

This impressive installation at Kiruna, Sweden, demonstrates a major benefit of ASEA Multi-Rope Friction Hoists: *low initial installation cost.*

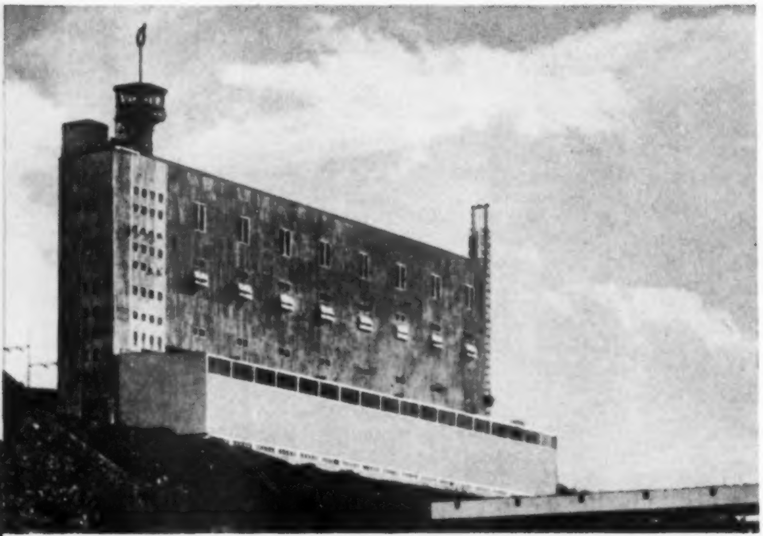
Each of these ASEA Hoists has a skipload of 22 tons and is designed for a depth of 1500 feet, maximum speed 2200 feet per minute.

At Kiruna, as in mining operations throughout the world, ASEA Multi-Rope Hoists prove less costly to operate, safer, and they reduce rope wear.

In the U.S. these advantages may be seen in the ASEA installations of National Potash Co. and The Cleveland-Cliffs Iron Company.

9 HOISTS IN ONE HEAD FRAME

Total capacity: 4600 tons per hour



FULLY AUTOMATIC, the ASEA Hoists at Kiruna eliminate the employment of hoist men.
At U.S. wage rates, assuming two-shift operation, this would mean a saving of about $30,000 yearly for each hoist!

Write for illustrated literature on ASEA Multi-Rope Friction-Drive Mine Hoists.

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World pioneer in electrical products for industry

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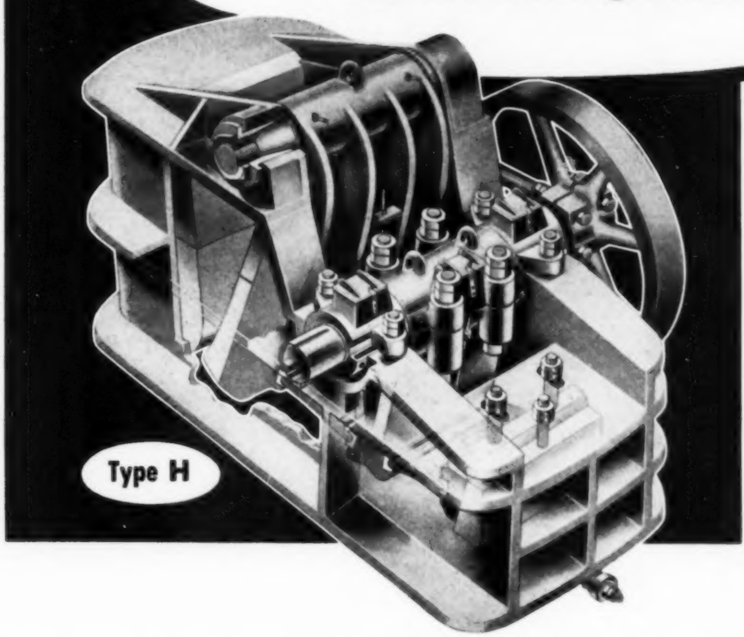
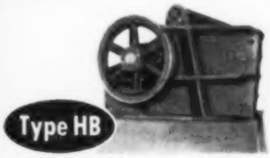
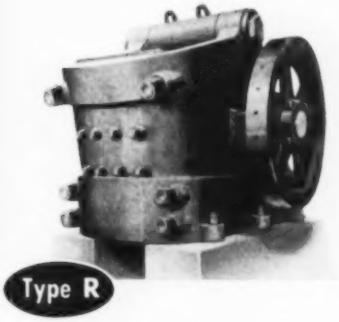
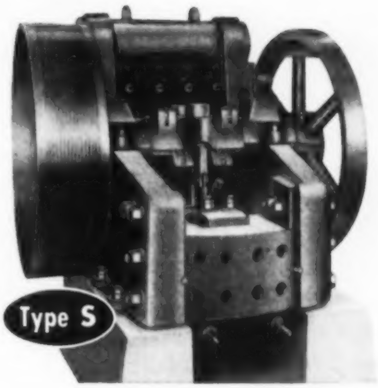
JAW CRUSHERS
for the mining industry









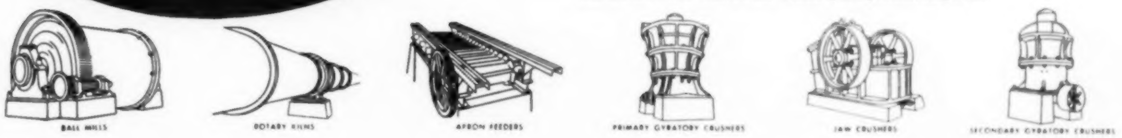
Four types of the hundreds of Traylor Jaw Crushers used throughout the world — with over half a century of engineering experience and know-how built into each. Features include non-chokable smooth-faced curved jaw plates, which allow for greater capacity at fine setting and longer life of wearing plates. Frames are reinforced at critical points to provide strength without excessive weight. Write for bulletins: Type H, 6105; Type HB, 104; Type R, 1123; Type S, 125.

Traylor

TRAYLOR ENGINEERING & MFG. CO., 1103 MILL ST., ALLENTOWN, PA.

Sales Offices: New York — Chicago — San Francisco

Canadian Mfr.: Canadian Vickers, Ltd., Montreal, P. Q.



Barter Program Reenlisted, With Additions

The Government's plan for bartering surplus U. S. agricultural commodities for needed strategic minerals, with nations that cannot pay in dollars, has been revived after its halt in September 1958. A list of 26 acceptable minerals has been drawn up to replace the old list of 12. While the program rids the nation of part of its farm glut, it also leads to criticism by competing farm product export nations, such as Canada. The U. S. Department of Agriculture, which handles the transactions, has been instructed to avoid market disruptions in its barter dealings. The following acceptable materials have been specified: crude aluminum oxide abrasives; antimony; asbestos (amosite, crocidolite); bauxite (Surinam, Jamaican, refractory); beryl (hand-cobbed); bismuth; cadmium; chromite (metallurgical, refractory, chemical); columbite; cryolite; diamonds and bort; ferro-chrome; fluorspar (acid, metallurgical); lead; manganese (commercial and natural grade A battery, type A and B chemical grade); mercury; mica (muscovite block, film, splittings); nickel; palladium; quartz crystals; ruthenium; selenium; silicon carbide; tantalite; tin; zinc.

AEC Ends Uranium Purchase Guarantee

The Atomic Energy Commission on November 21, 1958, withdrew its May 24, 1956, guarantee to purchase U_3O_8 in concentrates produced and delivered during the period April 1, 1962, to December 31, 1966. In order "to hold uranium production in reasonable balance with requirements," the commission said it would end its guarantee to purchase ore from reserves discovered and developed from now on. Some contracts now standing will be extended beyond 1962, but will not necessarily continue to 1966. It appears that the new order creates a market for ore reserves developed during the past year at the $8 per lb rate for concentrates.

Engineering Enrollments Fell Heavily in 1958

Freshmen enrollments for engineering degrees in 1958 were down a hefty 7.6 pct from the 1957 levels. Overall college enrollments, on the other hand, reached record highs.

Heavy Increase in Taconite Shipments Predicted

Referring to 1957 shipments of iron ore from the Lake Superior region in which taconite-derived pellets totaled 6.5 pct, A. Hoffman, president, Mesabi Iron Co., predicted the percentage figure would rise to 40 pct in 15 years or less.

Kennecott Dedicates Ray Mines Smelter

Improved copper recovery from low grade ore will result from a new $20-million smelter recently dedicated at Ray Mines Div. of Kennecott Copper Corp. Ray ore will yield an additional 2 lb of copper per ton through leach-precipitation flotation. New facility is capable of processing 20,000 tons per month . . . . Kennecott has started construction of an electrolytic refinery near Baltimore. The 16,500 ton per month facility is expected to start operating during 1959.

International Iron Ore News

In the January to September period of 1958, Canadian mine shipments of iron ore declined to 11,613,789 tons from 17,634,592 a year ago. Export shipments for

the same period fell to 10,220,388 tons from 15,964,633 . . . . Mitsubishi Co., Japan, has been negotiating for the development of a privately-owned iron ore deposit north of Santiago, Chile. Deposit is estimated at 12 million tons . . . French iron ore output for 1958 is likely to exceed 60 million tons, an all-time record . . . . USSR news agency Tass claims Russian capital investment in the iron ore industry will soon be increased 2.6 times. Expansion of old areas and development of new ones are scheduled. Open pit mining will be stressed, says the agency. The percentage of open pit work in total mining will advance from 55.4 pct in 1957 to 69 pct in 1965.

Lead Producers Fear Finished-Metal Imports

Domestic lead producers are beginning to think the import quota system will give too little protection against the influx of foreign ore, concentrates, and metal. They believe the quotas may be circumvented by finished and semi-finished lead products upon which there are no quota restrictions. Representatives have approached the U. S. State and Interior Departments for a review of the situation.

Precious Metals Notes

Gold production for the first nine months of 1958 totalled some 1.22 million fine ounces . . . . Silver was selling at 89⅞¢ an ounce after a ¼¢ cut in December. Total U. S. silver output for the first ten months of 1958 was up slightly over the same 1957 period . . . . Platinum producers cut the price of their metal by $5 to $52 an ounce, mainly because of heavy Russian offerings in London. But the market was also affected by decreased demand by the oil and electrical industries and the Government announcement that it would sell a large stock of scrap platinum.

Artificial Quartz Crystals

A Western Electric pilot plant is turning out synthetic quartz crystals that compete in price with the natural product, reports the manufacturing subsidiary of American Telephone & Telegraph Co. The potentially-commercial process combines pressure and heat to grow crystals that sell at about $30 per lb. Usual source is Brazil, where natural crystals of desired quality are becoming difficult to obtain.

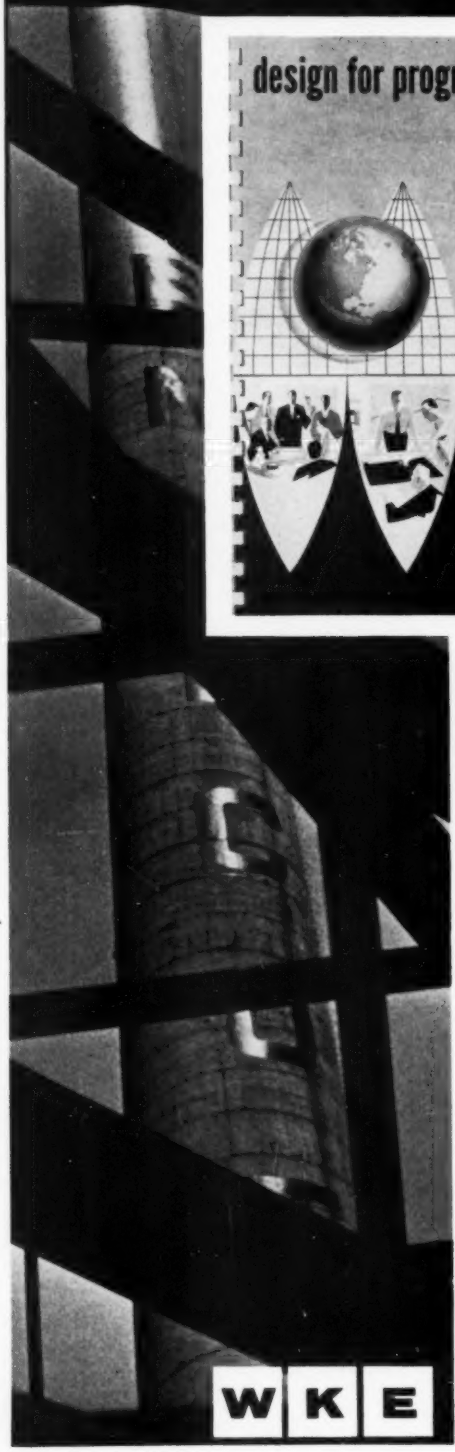
Custom Copper Smelters Cut Price

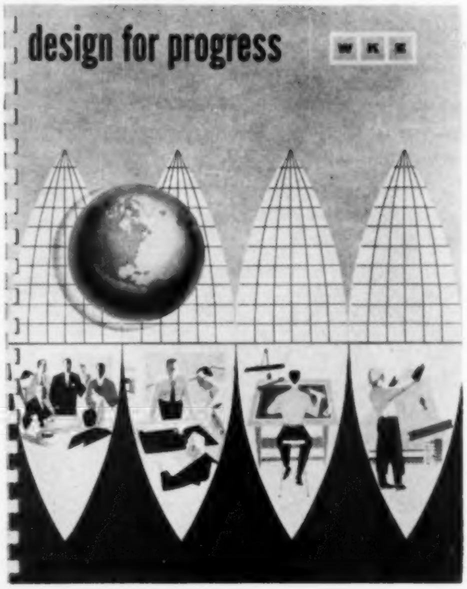
Custom smelter copper, quoted at 30¢ per lb since October 20, began its first decline since August 6, falling to 28½¢ in early December. The decline was attributed to a decrease in domestic demand after heavy inventory buying by fabricators in October and a fall-off of export sales. The primary producers meanwhile continued to report fair sales at their 29¢ quotation.

Soft Coal Prices Up

Soft coal producers will pass along to consumers part of the increased production costs resulting from higher wage agreements with the United Mine Workers. The 180,000 union members started the first of the year with a pay increase of $1.20 a day. A further upstep of 80¢ has been set for April 1.

MORE PLANT PER DOLLAR SPENT!





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of the WKE approach to modern plant development . . . and how it consistently has produced the right plant for the need—on schedule, within budget—the world over.

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The men of WKE have a story to tell through the pages of this new book just released. You'll be interested if you are concerned with a sound, proved, *profitable* approach to plant expansion or development.

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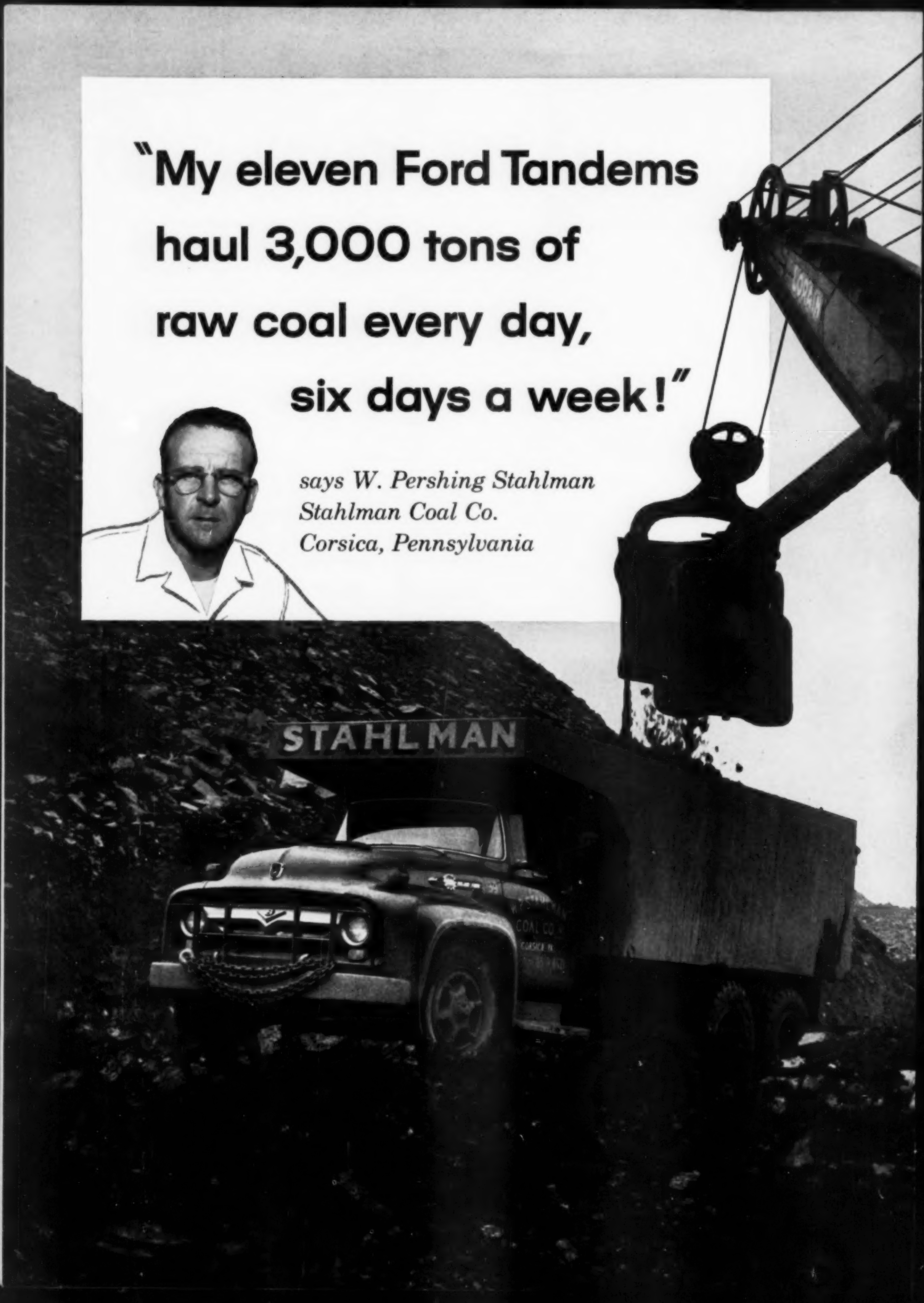
"My eleven Ford Tandems haul 3,000 tons of raw coal every day, six days a week!"
says W. Pershing Stahlman
Stahlman Coal Co.
Corsica, Pennsylvania
STAHLMAN

LETTERS

Fugitive Earthquake

Information about fugitive earthquakes in Nevada is being sought by David B. Slemmons, professor of geology at the Mackay School of Mines, University of Nevada, Reno. Dr. Slemmons is cataloging all historic earthquakes in the state before 1915. He believes there were several little-known quakes in Nevada's early history. Some of these may have given important ground breakage along faults.

There was probably an earthquake near the Wonder mine, 30 miles east of Fallon, anytime between 1900 and 1910. Dr. Slemmons hopes to find old newspaper clippings or diaries with clues to the exact time, or even old-time residents who could recall when the quake was felt.

Dr. Slemmons said that the history of Nevada earthquakes after 1915 is almost complete, thanks to seismograph records. He would appreciate any information that includes the exact date on which earlier earthquakes occurred, the damage if any, the area in which the shock was felt, and the location of any ground breakage.

Aluminum Economics

Dear Editor:

I am at present working on a study on aspects of the economics of integration of the bauxite-alumina-aluminum industry. It has become increasingly clear that some of the significant articles on recent developments relating to the economics of the industry are in languages other than English—particularly French and German. I have in mind, for example, *L'Industrie de l'Aluminium en Afrique Noire* by Louis Henin. I am giving thought to the possibility of translating a number of the more valuable of these papers and seeking permission to bring them out together in one volume in English.

I should welcome the suggestions of members of the organization of foreign papers which should be considered for translation into English for publication. The papers would all relate to economic aspects of the bauxite-alumina-aluminum industry.

H. D. Higgins
Director
Inst. of Social & Economic Research
University College of the West Indies
Mona, Jamaica, B.W.I.

Ed. Note: *We are sure Dr. Higgins will welcome suggestions. These should be sent directly to him.*

Abstracts

Dear Sir:

I would like to congratulate you on the new feature in the last two issues of MINING ENGINEERING, *Abstracts.*

This is just what I had been discussing with some of my associates and hoping it would be possible in technical publications.

I hope you maintain this feature in further issues . . .

Sincerely yours,

William Lodding
Associate Research
Bureau of Mineral Research
Rutgers, the State University
New Brunswick, N. J.

PROGRAM—SOCIETY OF MINING ENGINEERS

AIME Annual Meeting, February 15 to 19, San Francisco

Headquarters for the SME sessions and social functions during the AIME Annual Meeting will be the Sheraton-Palace Hotel. In the program, the following abbreviations indicate Divisional or other organizational sessions: *Coal*, Coal Division; *EMD*, Extractive Metallurgy Division of The Metallurgical Society of AIME; *IndMD*, Industrial Minerals Division; *MBD*, Minerals Beneficiation Division; *M&E*, Mining and Exploration Division; and *SEG*, Society of Economic Geologists, which is holding some separate and some joint sessions with SME Divisions. The Mineral Economics sessions are sponsored by the Council of Economics of AIME. Papers for which preprints are available are followed by a bold-face number. These may be obtained **only** by mailing SME coupon (see page 38).

SATURDAY, FEBRUARY 14, AM

AIME — Council of Section Delegates

10:00 am — Sheraton-Palace — Comstock Room

SUNDAY, FEBRUARY 15, PM

AIME — Council of Education

2:00 pm — Sheraton-Palace — Comstock Room

SME — The Future of the Mineral Industries And the Educational Requirements For Its Engineers

Charles F. Park, Jr., *Chairman*

Exploration Developments: *Arthur Brant*, Newmont Exploration Co. Ltd.

Let's Mechanize Underground Mining: *Roger Pierce*, Salt Lake City.

Problems and Progress in Mineral Dressing: *Norman L. Weiss*, American Smelting & Refining Co.

Some Problems and Some Opportunities in the Industrial Minerals Field: *F. C. Kruger*, International Minerals & Chemical Corp.

Preregistration Counseling for Mineral Industries Students at Penn State: *John J. Schanz, Jr.*, Pennsylvania State University. **59J19**

AIME — Board of Directors

2:00 pm — Sheraton-Palace — Comstock Room

AIME — Council of Education

Cocktails and Dinner

5:00 pm — Sheraton-Palace — Rose Room

Presentation of Mineral Industry Education Award to *Allison Butts*, Lehigh University.

AIME — Council of Education

Evening Session

8:00 pm — Sheraton-Palace — Concert Room

MONDAY FEBRUARY 16, AM

SME — Authors' Breakfast

8:00 am — Sheraton-Palace — Comstock Room

Coal — Coal Mining Methods

9:30 am — Sheraton-Palace — French Parlor

Jesse F. Core and O. A. Glaeser, *Chairmen*

Hydraulic Mining of Gilsonite and Its Application to Coal Mining: *J. H. Baker*, American Gilsonite Co. **59F3**

Faults in Pitching Coal Seams—Their Effect on Mining and Their Solution: *R. H. Carpenter*, Colorado School of Mines, and *Albert M. Keenan*, Thompson Creek Coal & Coke Co.

Reducing the Bounce Hazard at Sunnyside: *L. P. Hunstman* and *H. H. Elkin*, Kaiser Steel Corp. **59F90**

IndMD — Ceramic Raw Materials

9:30 am — Sheraton-Palace — Cafe

Richard F. Brooks and Charles Sweetwood, *Chairmen*

Major Clay Basins of the Pacific Coast—Panel Discussion.

1) Major Clay Basin of Western Washington and Oregon: *Hal J. Kelly*, U. S. Bureau of Mines.
2) Southern California Clay Basin: *Meredith C. Brown*, Whittier, Calif.
3) Major Clay Basins of the West Coast: *Robert W. Gates*, Gladding, McBean & Co.

MBD — Crushing and Grinding

9:00 am — Sheraton-Palace — Comstock Room

E. C. Herkenhoff and R. K. Poull, *Chairmen*

The Gyratory Ball Mill, Its Principle of Operation and Performance: *A. W. Fahrenwald*, Moscow, Idaho. **59B35**

Crushing Practice at Reserve Mining Co. Operations: *A. S. Henderson, E. M. Furness*, and *F. E. McIntire*, Reserve Mining Co. **59B63**

Pebble Milling Practice in the Reduction Works of the Gold Mines of Union Corp. Ltd.: *O. A. E. Jackson*, Union Corp. Ltd. **59B17**

Effects of Thermal Treatments on Grindability: *F. M. Stephens, Jr.*, and *A. L. Wesner*, Battelle Memorial Inst. **59B44**

Confirmation of the Third Theory: *F. C. Bond*, Allis-Chalmers Mfg. Co. **59B32**

M&E — Geochemical Techniques

9:30 am — Sheraton-Palace — Room A & B

H. E. Hawkes and Stanley Ward, *Chairmen*

Fluorescent X-Ray Spectrographic Analysis in Geochemical Prospecting: *M. L. Salmon*, Fluo-X-Spec Laboratory, and *H. E. Hawkes*, University of California.

Trace Elements in Pyrite from the Bingham District, Utah: *W. Parry, J. Brooke*, and *M. P. Nackowski*, University of Utah.

Reconnaissance Exploration by Analysis of Heavy Mineral Concentrates: *P. K. Theobald, Jr.*, and *C. E.*

Thompson, U. S. Geological Survey.

Soil Sampling as a Guide to Ore in the Copper Belt of Vermont: *Frank C. Canney*, U. S. Geological Survey.

A Comparison of Plant and Soil Prospecting for Nickel: *Charles P. Miller*, Phelps Dodge Corp. **59L40**

M&E Underground Mining I

9:30 am Sheraton-Palace Concert Room

Richard S. Newlin and Frank Coolbaugh, *Chairmen*

Mining at Gaspe Copper: *W. G. Brissenden* and *J. A. Hall*, Gaspe Copper Mines Ltd. **59AU64**

Long Hole Drilling as an Aid to Mining and Development Work at United Park City Mines Co.: *G. W. DeLaMare*, United Park City Mines Co. **59AU75**

The Seismic Wave from Plaster and Drill-Hole Explosive Charges: *A. W. Ruff*, Cananea Consolidated Copper Co.

Ground Movement and Subsidence from Block Caving at Miami Mine, Miami, Ariz.: *J. B. Fletcher*, Miami Copper Co. **59AU27**

SME Board of Directors Meeting

10:00 am Sheraton-Palace Bonanza Room

MONDAY, FEBRUARY 16, PM

Welcoming Luncheon

12:00 noon Sheraton-Palace Garden Court & Rose Room

Council of Education Business Meeting

12:00 noon Sheraton-Palace Room 2060

A. B. Kinzel, *Presiding*

Speaker: *Glen T. Seaborg*, University of California

Coal Coal Preparation I

2:30 pm Sheraton-Palace French Parlor

Frank Zachar and H. F. Yancey, *Chairmen*

Cleaning Plant Design for Economical Operation: *James D. Reilly*, Hanna Coal Co.

Cleaning Plant Design for Minimum Operating Labor: *J. D. Price* and *W. Bertholf*, Colorado Fuel and Iron Co. **59F5**

Design for Minimum Maintenance Labor and Supplies: *Albert P. Massman*, Peabody Coal Co.

IndMD Chemical Raw Materials

2:30 pm Sheraton-Palace Cafe

Roy P. Full and William M. Zilbersher, *Chairmen*

The Grand Isle Mine—Freeport Sulphur Co.'s Offshore Venture: *Z. W. Bartlett*, *C. O. Lee*, and *R. H. Feierabend*, Freeport Sulphur Co.

Fluorspar for Water Treatment: *F. J. Maier*, U. S. Public Health Service.

Ammonium Nitrate Blasting in Potash Mining: *A. V. Mitterer* and *S. A. Scott*, International Minerals and Chemical Corp. **59H60**

Recovery of Phosphates by In Situ Fluid Mining: *Sylvain J. Pirson*, The University of Texas. **59H4**

Colemanite as an Important Source of Borates: *W. T. Griswold*, Kern County Land Co. **59H20**

Potash in Saskatchewan: *Marion A. Goudie*, Winsal of Canada Ltd. **59H16**

MBD Concentration

2:30 pm Sheraton-Palace Comstock Room

R. H. Lowe and R. J. Mellen, *Chairmen*

Scrubbing of Mesabi Range Intermediate Iron Ores: *W. R. Van Slyke*, Cleveland-Cliffs Iron Co., and *R. C. Ferguson*, Hardinge Co. **59B58**

Consideration of Practical Ore Dressing Problems That Are Seemingly at Variance with the Theoretical: *C. J. Veale*, Fresnillo Zacatecas. **59B67**

Two Years Milling at Bicroft Uranium Mines Ltd.: *D. F. Lillie*, *W. J. Dengler*, and *I. C. Edwards*, Bicroft Uranium Mines Ltd. **59B52**

High Intensity Magnetic Separation of Iron Ores: *Ossi E. Palasvirta*, Oliver Iron Mining Div., U. S. Steel Corp. **59B73**

Ferrograde Concentrates from Arkansas Manganiferous Limestone: *M. M. Fine*, USBM. **59B25**

M&E Geophysical Techniques

2:30 pm Sheraton-Palace Concert Room

H. Bloom and J. S. Summer, *Chairmen*

AFMAG—A New Airborne Electrical Prospecting Method: *S. H. Ward*, Toronto.

Uses of Induced Polarization as a Geophysical Tool: *P. G. Hallof*, McPhar Geophysics Ltd.

Some Applications of Seismic Bedrock Investigations in Ore Prospecting: *J. C. Stam*, Hunting Technical & Exploration Services Ltd. **59L38**

The Application of the Methods of Operations Research to Prospecting: *Robert J. Uffen*, Universtiy of Western Ontario.

The Canadian Aero/Newmont Helicopter-Borne EM System: *R. H. Pemberton*, Canadian Aero Service Ltd. **59L39**

Measurement of Physical Properties of Iron Formation and Associated Rocks in the Lake Superior Region: *Charles J. Zablocki*, U. S. Geological Survey.

M&E Underground Mining II

2:30 pm Sheraton-Palace Rose Room

A. H. Shoemaker and Mayer G. Hansen, *Chairmen*

Algom Nordic—Development to Production: *Murray W. Airth* and *E. R. Olson*, Algom-Uranium. **59AU71**

Pillar Recovery at the Mi Vida Mine: *Virgil A. Bilyou* and *Theodore J. Barrett*, Utex Exploration Co.

Mining Problems and Developments at Ambrosia Lake, New Mexico: *D. T. Delicate*, Homestake Mining Co.

Underground Storage for Hydrocarbon Fluids: *Robert L. Loofbourow*, Minneapolis. **59AU82**

AIME Cocktail Party

6:00 to 7:30 pm Sheraton-Palace Registration Area

AIME Stag Dinner-Smoker

8:00 pm Sheraton-Palace Garden Court

TUESDAY, FEBRUARY 17, AM

MBD Scotch Breakfast

7:30 am Sheraton-Palace Ballroom

As Concocted by the Honorary Chefs

SME Authors' Breakfast

8:00 am Sheraton-Palace Comstock Room

MBD Business Meeting

8:30 am Sheraton-Palace Comstock Room

Coal Coal Preparation II

9:00 am Sheraton-Palace French Parlor

D. A. Dahlstrom and Paul L. Richards, *Chairmen*

Wellington Preparation Plant: *Loring McMorris,* Columbia-Geneva Steel Div., U. S. Steel Corp.

Characteristics of Coal Preparation Plant Slurries: *H. B. Charmbury* and *D. R. Mitchell,* Pennsylvania State University. **59F86**

A Laboratory Investigation of Flocculation as a Means of Improving Filtration of Coal Slurry: *M. R. Geer, P. S. Jacobson,* and *H. F. Yancey,* USBM. **59F34**

AIME **Council of Economics**

Appraisal of Paley Report

9:00 am Sheraton-Palace Cafe

Sheldon P. Wimpfen, *Chairman*

Copper, Lead and Zinc: *Evan Just,* Scarsdale, N. Y. **59K65**

The Light Metals and the Paley Report: *Walter Rice,* Reynolds Mining Corp. **59K31**

Industrial Minerals 1950-1958-1975, With Special Emphasis on Fluorspar: *Raymond B. Ladoo,* Newton, Mass. **59K23**

Iron and Steel; The Paley Report in Retrospect: *John D. Sullivan,* Battelle Memorial Inst. **59K48**

Current Trend of Production and Consumption of Sources of Energy: *Eugene Ayres,* Gulf Oil Corp. **59K76**

M&E **Health, Safety & Personnel**

9:00 am Sheraton-Palace Rose Room

James Westfield and Cliff S. Gibson, *Chairmen*

Safety Organization at Braden Copper Co.: *Stanley Jarrett.* **59AU72**

A Campaign for the Elimination of Accidents at the Lavender Pit, Copper Queen Branch, Phelps Dodge Corp.: *W. K. Pincook,* Phelps Dodge Corp. **59AU84**

Industrial Relations at Kennecott Copper: *Edward Flynn,* Kennecott Copper Corp.

SME **Nominating Committee Meeting**

10:00 am Sheraton-Palace Room 2127

MBD **Mill Design**

10:00 am Sheraton-Palace Comstock Room

Harry L. McNeill and Charles N. Bailey, *Chairmen*

Operation and Maintenance Improvements in a Large Taconite Plant Are Facilitated by Good Basic Engineering Design: *R. J. Linney,* Reserve Mining Co. **59B68**

Design Requirements for Tailing Disposal in the Southwest: *E. V. Given,* San Manuel Copper Corp. **59B12**

Semi-Dome Shaped Buildings for Bulk Storage: *Edward E. Ives* and *W. L. Payne,* Stearns-Roger Manfacturing Co. **59B13**

Some Design Aspects of Large Uranium Mills: *D. J. McParland,* Rio Tinto Mining Co. **59B81**

MBD **Selected Topics**

10:00 am Sheraton-Palace California Room

Fred D. DeVaney and Robert H. Oliver, *Chairmen*

Production of Self-Fluxing Pellets in the Laboratory and Pilot Plant: *K. Merklin* and *F. D. DeVaney,* Pickands Mather & Co. **59B88**

Physical Chemical Aspects of Flocculation by Polymers: *W. F. Linke* and *R. B. Booth,* American Cyanamid Co.

Flocculation—Key to More Economical Liquid-Solids Separation: *R. H. Oliver,* Dorr-Oliver Inc. **59B78**

The R-N Rotary Kiln Process for Reduction of Iron Ore: *O. Mokelbust,* R-N Corp. **59B70**

The Magnetic Susceptibilities of Rutile and Sphene: *S. C. Sun, D. R. Mitchell,* and *D. J. Cook,* The Pennsylvania State University.

TUESDAY, FEBRUARY 17, PM

Coal **Division Luncheon**

12:00 noon Sheraton-Palace Cafe

Speaker: *K. M. Robinson,* Washington Water Power Co.

IndMD **Division Luncheon**

12:00 noon Sheraton-Palace Cafe Lobby Floor

Speaker: *George F. Taylor,* Lockheed Aircraft Corp.

Mining and Metallurgical Society of America Luncheon

12:00 noon Sheraton-Palace English & California Rooms

SEG **Council Meeting**

2:30 pm Sheraton-Palace Room 2062

AIME **All Institute Session**

2:30 pm Sheraton-Palace Garden Court

Speaker: *Roger Revelle,* Scripps Inst. of Oceanography

AIME **Annual Business Meeting**

4:00 pm Sheraton-Palace Garden Court

A. B. Kinzel, AIME President, Presiding

Coal **Division Business Meeting**

4:00 pm Sheraton-Palace French Parlor and Gallery

AIME **Board of Directors**

5:00 pm Sheraton-Palace Comstock Room

Society of Mining Engineers Dinner

6:00 pm Cocktails Sheraton-Palace Concert Room Lobby Floor

7:00 pm Dinner Sheraton-Palace Rose Room Lobby Floor

Toastmaster: *S. D. Michaelson,* SME President

Introduction: *J. W. Woomer,* 1959 SME President

AIME **Informal Dance**

9:00 pm The Village Columbus at Lombard St.

WEDNESDAY, FEBRUARY 18, AM

SME **Authors' Breakfast**

8:00 am Sheraton-Palace Comstock Room

Coal

Coal Mine Safety & Industrial Relations

9:00 am Sheraton-Palace French Parlor

C. A. Peterson and Everett M. White, *Chairmen*

Mine Communication System At San Manuel: *C. L. Pillar,* San Manuel Copper Corp. **59F80**

Are Mine Employes and Dollars Protected From Fire As Well As Industrial Employes and Dollars? *R. Ward Stahl,* U. S. Bureau of Mines. **59F26**

An Investigation of Materials Used for Stoppings in Coal Mine Ventilation System: *Charles T. Holland,* Virginia Polytechnic Inst. and *W. J. Skewes,* Pocahontas Fuel Co.

Safety with Continuous Miners and Other Mechanized Equipment in Pitching Coal Beds: *L. H. McGuire,* USBM. **59F87**

Rare and Radioactive Minerals
IndMD-SEG

9:00 am Sheraton-Palace Cafe

Ian Campbell and Lauren A. Wright, *Chairmen*

Geology of the Montgary Pegmatite: *Richard W. Hutchinson*, Toronto. **59H46**

Environmental Factors Governing the Origin and Distribution of Heavy-Mineral Deposits on Padre Island, Texas, A Barrier Island: *Louis Moyd*, N. Y.

Thorite and Rare Earth Deposits in the Lemhi Pass Area, Lemhi County, Idaho: *Alfred L. Anderson*, Cornell University.

Radiographic Distribution Analysis Applied to Uraniferous Pyrite, Galena, and Sphalerite: *H. D. Wright, J. J. Hutta, W. P. Shulhof*, and *C. M. Smith*, The Pennsylvania State University.

Economic Uranium Deposits in Granitic Dykes, Bancroft District, Ontario: *S. C. Robinson*, Geological Survey of Canada.

MBD Symposium: Solids-Fluid Separation

9:00 am Sheraton-Palace Comstock Room

D. A. Dahlstrom and J. D. Vincent, *Chairmen*

Counter-Current Decantation—When and Why?: *E. J. Roberts*, Dorr-Oliver Inc.

Design Aspects of Counter-Current Decantation: *H. L. Hazen*, H. L. Hazen Inc.

Thickening Leach Residues in the Sherritt-Gordon Nickel Refinery: *D. J. I. Evans* and *A. J. Lindsay*, Sherritt-Gordon Mines Ltd. **59B37**

Separation and Washing of Alumina Process Residue: *Morton Handelman*, Reynolds Metal Co. **59B10**

M&E Symposium: Exploration Problems

9:00 am Sheraton-Palace Concert Room

H. E. McKinstry, *Chairman*

Panelists:

Management—*James Boyd* and *C. White*
Government—*C. Anderson* and *J. Harrison*
Geology—*H. Schmitt* and *C. P. Jenney*
Geophysics—*H. Seigel*
Geochemistry—*H. E. Hawkes* and *J. Riddell*

M&E Open Pit I—Drilling and Blasting

9:00 am Sheraton-Palace Rose Room

A. E. Millar and A. J. Gould, *Chairmen*

Expansion and Development of Transportation System in Chuquicamata: *Robert Laurich*, Chile Exploration Co. **59A049**

Drilling Methods and Equipment at New Cornelia Open Pit Mine: *John E. O'Neill*, Phelps Dodge Corp. **59AO79**

Ammonium Nitrate Blasting Agents: *Louis W. Towle*, Apache Powder Co.

Firing Fertilizer for Fragmentation: *John R. Knudson*, The Cleveland-Cliffs Iron Co. **59A029**

Blasting with Commercial Grade Ammonium Nitrate at Utah Copper Pit: *L. E. Snow*, Utah Copper Co. **59AO83**

IndMD Business Meeting

10:00 am Sheraton-Palace Room 2127

WEDNESDAY, FEBRUARY 18, PM

M&E Division Luncheon

12:00 noon Sheraton-Palace Rose Room

Peele Award to *F. R. Jones*, Stanrock Uranium Mines Ltd.

Jackling Award to *R. S. Archibald*, North Range Mining Co. (See *Jackling Lecture* p. 37)

Coal Power and Automation

2:00 pm Sheraton-Palace French Parlor

C. L. Sarff and Stephen Krickovic, *Chairmen*

The Advantages of AC Power for Underground Mines: *Wendell C. Painter*, Joy Manufacturing Co.

AC Power Distribution for Underground Mining: *W. B. Jamison*, Jamison Coal Co.

The Automation of Mining: *Gerald von Stroh*, Bituminous Coal Research Inc.

AIME Council of Economics
Mineral Economics

2:00 pm Sheraton-Palace Ballroom

Sheldon P. Wimpfen, *Chairman*

Expected Realignments in the Next Five Years: *Samuel G. Lasky*, U. S. Dept of The Interior. **59K22**

The Role of the Mineral Engineer in Industrial Development and Area-Planning Programs: *H. W. Straley, III*, Georgia Inst. of Technology.

The Role of Mineral Economics in Area Planning and Industrial Development: *John E. Husted*, Georgia Inst. of Technology.

Trends in Real Prices of Representative Minerals Commodities 1890-1957: *Charles W. Merrill*, U. S. Bureau of Mines. **59K21**

IndMD Water Problems

2:00 pm Sheraton-Palace Cafe

Leon W. Dupuy and Richard M. Foose, *Chairmen*

Water Laws as Related to Dredging in Idaho: *R. P. Porter, R. B. Porter, and R. A. Lothrop*, Porter Brothers Corp. **59H9**

Land Subsidence in the San Joaquin Valley, California—Methods of Investigation and Preliminary Findings: *J. F. Poland*, U. S. Geological Survey.

Water Law and Its Significance to the Mining Industry: *Wells A. Hutchins*, U. S. Dept. of Agriculture. **59H1**

Relation of Land Subsidence to Ground-Water Withdrawals in the Upper Gulf Coast Region, Texas: *A. G. Winslow* and *Leonard A. Wood*, USGS **59H2**

MBD-EMD
Chemical Process—Nickel

2:00 Sheraton-Palace Comstock Room

John Dasher and M. E. Wadsworth, *Chairmen*

Film Premier: ——————— International Nickel Co.

Refining of Ni-Cu-Co Mattes by Pressure Leaching and Hydrogen Reduction: *R. F. Pearce, J. P. Warner*, and *Y. N. Mackiw*, Sheritt-Gordon Mines Ltd. **59B41.**

Co-Ni Separation—An Investigation of the DeMerre Process: *D. W. Bridges*, U. S. Bureau of Mines.

Modifications in Nicaro Metallurgy: *Armando Alonso* and *John Daubenspeck*, Nickel Processing Corp.

Ammonium Sulfate Leaching—Hydrogen Reduction Process for Treating Nicaro Bulk Precipitate: *James Shea*, Battelle Memorial Inst.

M&E Open Pit II—Loading and Haulage

2:00 pm Sheraton-Palace Rose Room

E. A. Friedman and W. S. Moore, *Chairmen*

Planning, Developing, and Operating the Berkeley Pit: *C. C. Goddard, Jr.; P. M. Young; F. Ralph;* and *E. O. Bonner*, The Anaconda Co. **59A050**

Selection of an Open Pit Haulage Method: *W. N. Matheson*, U. S. Steel Corp., **59A036**

Improvements in Loading and Hauling Equipment and Their Effect on Unit Costs: *Charles S. Davis*, Utah Construction Co. **59A055**

Replacement of Capital Equipment: *H. J. Schwellenbach*, New York Trap Rock Corp.

SEG **Economic Geology**

2:00 pm Sheraton-Palace Concert Room

Kenneth L. Cochran and John H. Melvin, *Chairmen*

Relation of Magnetic Anomalies to Some Geologic Structures in Northern Minnesota: *Gordon D. Bath*, U. S. Geological Survey.

Aeromagnetic Effects of Igneous Features in Northern Minnesota: *George M. Schwartz*, Minnesota Geological Survey.

Structural Environment of the Illinois-Kentucky Fluorspar District: *M. P. Nackowski*, Salt Lake City.

Structures Related to Solution of Borax at Kramer, Calif.: *Ward C. Smith*, U. S. Geological Survey.

The Alhambra Co-Ni-Ag Deposit, Black Hawk (Bullard Peak) District, New Mexico: *Elliot Gillerman*, University of Kansas.

A Concept of the Origin of Porphyry Copper Deposits: *C. W. Burnham*, The Pennsylvania State University.

M&E **Jackling Lecture**

3:00 pm Sheraton-Palace Cafe Grill

Economic History of the Lake Superior Iron District: *R. S. Archibald*, North Range Mining Co. **59A91**

M&E **Business Meeting**

4:00 pm Sheraton-Palace Cafe Grill

AIME **Annual Banquet**

7:00 pm Sheraton-Palace Garden Court

Presiding: *Augustus B. Kinzel*, AIME President

Presentation of AIME Awards and Insignia of Legion of Honor

Introduction of and Speech by Incoming President: *Howard C. Pyle*

Reception in honor of 1959 President immediately follows Banquet.

THURSDAY, FEBRUARY 19, AM

SME **Authors' Breakfast**

8:00 am Sheraton-Palace Comstock Room

Coal **Coal Utilization**

9:00 am Sheraton-Palace French Parlor

Max A. Tuttle and James R. Garvey, *Chairmen*

What Can Be Expected From Coal Research?: *T. Reed Scollon*, U. S. Bureau of Mines. **59F43**

Removal of Sulfur Dioxide From Flue Gases At Elevated Temperature: *Daniel Bienstock* and *Joseph H. Field*, U. S. Bureau of Mines. **59F24**

Coal Characteristics and Their Relationship to Combustion Techniques: *T. S. Spicer* The Pennsylvania State University. **59F85**

The Integration of Coal Characteristics With the Design of Large Pulverized Coal Steam Generating Units: *Douglas G. Hubert*, Combustion Engineering. **59F30**

IndMD

Special Sands & Abrasives—Fillers, Fibers, & Pigments

9:00 am Sheraton-Palace Cafe

L. R. Moretti and George F. Pettinos, Jr., *Chairmen*

A Rapid Method for Estimating Alumina in Felspathic Sands: *Hugh H. Bein*, Del Monte Properties. **59H8**

Marketing Trends for Selected Mineral Fillers: *W. F. Dietrich*, U. S. Bureau of Mines. **59H89**

Diatomite—A Current Review: *Arthur B. Cummins*, Johns-Manville Corp. **59H53**

Man-Made Industrial Diamonds: *J. D. Kennedy*, General Electric Co. **59H57**

Glass Sand from the Ione Formation: *W. W. Slade* and *R. W. Heindel*, Owens-Illinois Co.

MBD **Symposium: Fatty Acid Flotation**

9:00 am Sheraton-Palace Comstock Room

F. T. Davis and G. L. Sollenberger, *Chairmen*

History of Soap Flotation: *George H. Roseveare*, Arizona Bureau of Mines. **59B51**

Single Mineral Flotation with Linolenic, Linoleic, Oleic, and Stearic Acids: *Shiou-Chuan Sun* The Pennsylvania State University.

Neo-Sulfide Flotation with Fatty Acid and Petroleum Sulfonate-Type Promoters: *Stuart A. Falconer*, American Cyanamid Co. **59B33**

Feed Preparation and Froth Modification for Fatty Acid Flotation: *Carl C. Martin* and *Burt C. Mariacher*, Colorado School of Mines Research Foundation Inc. **59B11**

M&E-SEG **Selected Geological Topics**

9:00 am Sheraton-Palace Rose Room

W. W. Simons and P. Joralemon, *Chairmen*

Quantitative Mineralogy as a Guide to Exploration: *R. J. P. Lyon* and *W. M. Tuddenham*, Kennecott Copper Corp. **59I77**

Tectonic Analysis as an Exploration Tool: *Peter Coles Badgley*, Colorado School of Mines. **59I69**

Genesis of the Scott Magnetite Deposit, Sterling Lake, N.Y.: *A. F. Hagner*, *L. G. Collins*, and *Tin Aye*, University of Illinois.

Deposits of the Manganese Oxides: *D. F. Hewett*, U. S. Geological Survey.

Geochemical Study of Pb-Ag-Zn Ore from the Darwin Mine, Inyo County, Calif.: *Wayne E. Hall*, U. S. Geological Survey. **59I47**

THURSDAY, FEBRUARY 19, PM

MBD **Division Luncheon**

12:00 noon Sheraton-Palace Ballroom

SEG **Luncheon**

12:00 noon Sheraton-Palace Rose Room

Coal **Carbonization and Gasification**

2:00 pm Sheraton-Palace French Parlor

C. F. Hardy and C. H. Sawyer, *Chairmen*

The Coal Pipeline: *T. J. Regan* and *V. D. Hanson*, Consolidation Coal Co.

Coke Combustibility—A Neglected Characteristic: *J. D. Price*, Colorado Fuel & Iron Co. **59F6**

Determination of Coke Oven Productivity From Coal Charge Characteristics: *A. H. Brisse*, U. S. Steel Corp. **59F74**

IndMD **Cement and Aggregates**

2:00 pm Sheraton-Palace Cafe

Orville E. Jack and E. L. Howard, *Chairmen*

Franciscan Chert in California Concrete Aggregates: *Harold B. Goldman*, California Div. of Mines

Aggregate in California: *T. E. Gay, Jr.*, California Div. of Mines.

Modern Classification Methods Applied to Fine Aggregates: *C. E. Golson*, Western Machinery Co. **59H61**

Co_2 Gas as a Cement Slurry Thinner: *Harold Potter* and *Duncan Williams*, Monolith Portland Midwest Co. **59H15**

Flow of Limestone and Clay Slurries in Pipelines: *Ross W. Smith*, Colorado School of Mines Research Foundation Inc. **59H14**

Measurement of Cement Kiln Shell Temperatures: *R.*

E. Boehler and N. C. Ludwig, Universal Atlas Cement Co. **59H56**

MBD-EMD

Chemical Process—Uranium

2:00 pm Sheraton-Palace Comstock Room

R. D. MacDonald and William Lennemann *Chairmen*

Leaching, Ion Exchange, and Precipitation of Blind River Uranium Ores: *K. D. Hester, A. G. Roach*, and *R. P. Ehrlich*, Rio Tinto Management Service. **59B28**

A Kinetic Study of the Dissolution of UO_2 in Sulfuric Acid.: *T. L. Mackay* and *M. E. Wadsworth*, University of Utah **59B42**

Working the Kinks Out of the Homestake-New Mexico Partners Mill: *Clyde N. Garman*, Homestake-New Mexico Partners. **59B54**

Union Carbide's Uranium Operation at Maybell, Colo.: *K. W. Lentz* and *F. T. Temple*, Union Carbire Corp. **59B7**

MBD **Materials Handling**

2:00 pm Sheraton-Palace California Room

R. L. Druva and Lester R. MacLeod, *Chairmen*

The Wobbler Feeder: *T. A. Oberhellmann*, St. Louis.

Flow of Bulk Solids—Progress Report: *A. W. Jenike, P. J. Elsey*, and *R. H. Woolley*, University of Utah. **59B62**

Belt Conveyor Power Studies: *A. W. Asman*, Hewitt-Robins Inc. **59B66**

Stockpiling Purposes, Methods, and Tools: *Laurance O. Millard*, Link-Belt Co. **59B59**

M&E Exploration Ventures—Case Histories

2:00 pm Sheraton-Palace Rose Room

S. E. Jerome and R. J. Lacy, *Chairmen*

The Bonanza Project, Bear Creek Mining Co.: *Douglas R. Cook*, Bear Creek Mining Co. **59L18**

A Technical Success: *D. J. Salt*, Ventures Ltd.

Geology and Exploration Developments, Mattagami Area, Northwestern Quebec: *C. P. Jenney*, Oakville, Ont., Canada.

The Esperanza Copper Mine—A Case History of Discovery: *Harrison A. Schmitt*, Silver City, N. M.

Anaconda Exploration in the Bathurst District of New Brunswick: *C. G. Cheriton*, The Anaconda Co. Ltd.

SEG **Council Meeting**

2:30 pm Sheraton-Palace Room 2062

Alumni Meetings

As MINING ENGINEERING went to press, the following organizations had announced that meetings would be held for alumni during the AIME Annual Meeting:

Michigan College of Mining & Technology
Missouri School of Mines & Metallurgy
University of California
Universtiy of Nevada

Consult the final program for place and time.

ADDITIONAL ABSTRACTS OF THE SOCIETY OF MINING ENGINEERS OF AIME

(See the December issue for Abstracts previously printed.)

A number following an abstract indicates that Preprints of this paper are available. As other preprints become available they will be listed in MINING ENGINEERING. These Preprints, prepared by the Society of Mining Engineers, are obtained only on a coupon basis. Coupon books (10 coupons) are $5 per book for members, $10 for nonmembers, and can be purchased from Preprint Dept., SME Headquarters, 29 W. 39th Street, New York 18, N. Y. *Each SME member received, with the AIME dues bills, a book containing five pink coupons, each of which, properly filled out, is valid for one free Preprint. In addition, each member who registers at the SME desk, San Francisco Annual Meeting, will receive an additional book of five free pink coupons.* If every member redeems coupons for Preprints, the Society will be distributing over 100,000 free papers. For this reason, if the program is eventually to become self-sustaining, all other Preprints must be distributed on a paid (green or yellow) coupon basis. In order that the interests of members be sustained, the Society allows members a discount on preprint coupon books. Nonmembers will be charged full price ($10) per coupon book. SME members are reminded that blue 1958 coupons expired on Dec. 31, 1958.

COAL DIVISION

Coal Preparation I

Cleaning Plant Design for Economical Operation by *James D. Reilly*—Numerous factors are involved in designing a cleaning plant for economical operation. Due consideration must be given to the preparation goals that are to be achieved in satisfying customer requirements. Refuse disposal, water supply, raw coal storage, and loading facilities are problems which greatly affect plant design. Assuming that proper study has been given to the engineering details, additional steps must be taken to assure a greater economy of operation: 1) It is imperative that the proper equipment for washing, drying, and sizing coal is selected. Automation merits the most careful study. 2) Maintenance can be a critical cost item. A very thorough maintenance program is a necessity, particularly preventive maintenance. 3) Where the human element is involved, properly trained personnel will materially increase production, which in turn reduces costs.

Coal Mine Safety And Industrial Relations

Mine Communication System at San Manuel by *Charles L. Pillar*—The paper covers the various types of communication and how they are used at this underground block caving mining operation. A brief technical description of the equipment and its installation is included.

Emphasis is placed on the important part this communication system has and is playing in coordinating a large, complex underground mining operation to meet high standards in safety and obtain maximum efficiency from the working force and their equipment.

The communication system itself is composed of three different methods of speech transmission: 1) a standard underground telephone system connecting all important surface and underground stations with standard telephone communication; 2) a two-way audio system used mainly in the mining area on both grizzly and haulage levels—here 50 audio stations allow supervision to efficiently coordinate operating functions of draw, haulage, repair, development, supply, and service with safety and a minimum amount of lost time and delay; and 3) a two-way trolley radio system on the haulage level with units installed in 25 operating locomotives and in key strategic places for use by dispatcher and supervision. Currently 1,000,000 tons of ore a month are hauled on this level a distance of 7,500 feet from the mining area to the hoisting shafts. In addition to the ore haulage, 13 trains are in continuous operation to handle necessary development, repair, service, supply, and clean up.

Good clear dependable communication is playing a most important part in maintaining a safe and efficient mining operation at San Manuel. **59F80.**

Are Coal-Mine Employes and Dollars Protected From Fire as Well as Other Industrial Employes and Dollars? by *R. Ward Stahl*—A survey of fire-fighting facilities in coal mines disclosed what appeared to be a lack of emphasis on fire protection in some mines and prompted a comparison with other heavy industry.

The contrast revealed by the study seemed to warrant dissemination of the information for those desirous of improving their protective effort.

Since mine surface buildings and offices in most cases were protected similarly to those in other industries, it might be assumed that the dark recesses of a mine not visited as often by high echelon officials and not so visible to general passersby are sometimes overlooked.

In most cases, more expensive equipment is concentrated in a smaller area of a mine than in other plants, yet generally the protection afforded to combat fire is far less.

Most plants can be evacuated in minutes while a mine may require hours and the hazards of escape are far greater. Gas may be ignited and blow out stoppings thus diverting contaminated air into fresh air channels, the surroundings are combustible, explosive dust is present, thus making escape from a mine fire more questionable than a plant fire.

In light of the findings of these studies a question arises as follows: Does the mine stockholder expect as much protection of his dollar as the stockholder in another industry? If he does, why do some mines: 1) render water supply ineffective by inserting small-diameter pipe in ample size lines, 2) neglect to test the fire hose to assure it is usable, 3) keep fire extinguishers so far from the scene of activity, and 4) neglect training of at least key men in fire-fighting procedure and emergency escape measures. **59F26.**

Power and Automation

Advantages of A-C Power for Underground Mines by *Wendell C. Painter*—Brief comparison of ac and dc electrical systems in underground mines, followed with electrical maintenance data from several western companies, some of which have had operating experience with ac underground equipment for 30 years or more.

Coal Utilization

What Can Be Expected from Coal Research? by *T. Reed Scollon*—Research expenditures for coal are at the level of about $17 million annually. Based upon national averages, research on coal is about one third the rate of other commodities. If the proper categories of additional coal research can be determined and a major expansion of the effort started, some real benefits to the coal industry, better coal conservation practices, and improved

health and safety practices and conditions should be expected.

Coal is a more refractory raw material than oil and natural gas, its chief competitors. Accordingly, mining and processes to upgrade, alter, or handle coal in any way are inherently more difficult than the same operations for these other fossil fuels.

Projects for an expanded coal research program are suggested and include: development of improved mining equipment and methods; development of more economic means of recovering and cleaning fine coal; degasification of coal seams in advance of mining; development of a commercial, stationary, coal-burning gas turbine; studies of the mechanism of coking; process improvements in the production of synthetic liquid, high-Btu gas and chemicals; and additional basic research on coal.

The question "What can be expected from coal research?" is difficult to answer. Perhaps because of the complex structure of coal and the unpredictable nature of research itself there is no definite answer. Much has been accomplished with relatively small expenditures in the past. Based upon the experiences of other industries and a realistic appraisal of coal's possible future, there is no doubt that increased coal research will in time further benefit the coal industry. **59F24.**

Carbonization and Gasification

Coal Pipeline by *T. J. Regan* and *V. D. Hanson*—This paper, prepared for oral presentation, describes a pipeline operation for transportation of coal as slurry. A detailed description is given of the methods used, and equipment for preparing the slurry. Also included are data on pipeline, pumping system, and dewatering plant.

Determination of Coke Oven Productivity From Coal Charge Characteristics by *A. H. Brisse*—The paper will discuss separately the influence of various coal charge characteristics such as bulk density, moisture content, carbonization pressure, volumetic contraction, heating rate, etc., on coke oven output and show how these variables can be represented on a single chart to permit the determination of maximum oven productivity quickly and simply. **59F74.**

INDUSTRIAL MINERALS DIVISION

Ceramics Raw Materials

Major Clay Basins of Western Washington and Oregon by *Hal J. Kelly*—Production of clay in western Washington for ceramic ware has been from deposits having three distinct geologic histories. In Oregon recent silts account for most of the industrial clay although altered volcanic material has provided other undeveloped sources.

The all-encompassing deposition of glacial material in Washington extends from the foothills of the Cascade Mountains to the marine shoreline and from the Canadian border to the Columbia River. It has provided glacial clay that is widely used in manufacture of structural products. This mantle has effectively obscured the very thick Eocene sediments that are composed of interstratified beds of sandstone, shale, and coal. The shales of the Puget group which are sporadically exposed over the area are a source of refractory and low-firing shales. Prospecting and mining of these shales has been complicated by very heavy vegetal and glacial covers, extensive folding, and complex faulting. Although this group of sediments has been the subject of extensive geological investigation owing to the coal measures found in them, geological correlation of the beds over the area has not been accomplished. In fact, correlation of the beds in adjacent areas is a matter for conjecture due to the extensive folding, faulting, and the similarity of interbedded shales and sandstones, complicated by the extreme thickness of some beds.

A third source of clay is the alteration products of Tertiary volcanics that overlie the sedimentary deposits. The rugged terrain, and severe glacial action have removed much of the clay formed in place, leaving only a thin topping of clay grading into the unaltered acidic volcanics. Some of the clay removed has been deposited in the valleys completely intermixed with clays from basaltic parent rocks. Most of the clays, however, probably found their way to the nearby ocean basin. The remaining alteration remnants are usually low temperature, white to red-firing clays, suitable only for structural products.

In Oregon a similar intermixing of white and red clays has occurred in the area east of Salem and extending to Eugene. There deposition was more extentive as the mountain front is considerably more distant from the existing marine basin. An additional mineralogical intermixing make these clays even less suitable for ceramic ware than those found in Washington. A large deposit of altered volcanics at Hobart Butte, near Cottage Grove, Ore., has produced some refractory clay of high quality but peculiar firing characteristics have retarded its development.

The trends of clay mineral occurrences throughout western Washington and Oregon and the details of the firing peculiarities of Hobart Butte clay are discussed along with the influence of geologic events on prospecting and mining clay.

Southern California Clay Basin by *Meredith C. Brown*—This paper describes the origin, occurrence, and physical and ceramic properties of the clays found in Riverside, Orange, and San Diego Counties, Calif. Illustrations show the various types of clays and their stratigraphic relationships. Prospects of finding new deposits are discussed.

Major Clay Basins of the West Coast by *Robert Gates*—The Ione formation of California lies along the foothills of the Sierra Nevada Mountains, where the rolling topography of the basement complex rocks changes to the level plain of the great valley. The formation consists of quartz sands and gravels, clays, and seams of lignite.

After its deposition, the Ione formation was covered by younger beds of Rhyolitic and Andesitic tufts and Pleistocene sediments, which have aided largely in the preservation of the Ione formation. Erosion has removed this covering at a number of places, leaving the Ione formation exposed at the surface.

Clays in the Ione Basin are classified in two geological groups: 1) residual and 2) sedimentary.

The surface on which the Ione sediments were deposited unconformably is very irregular. This surface shows evidence of great disturbance, with the general attitude of the bedding planes dipping northeast, striking southeast, and plunging westward in the McQuire Tract. Lithology of the basement complex rocks is that of a soft, weathered jurrassic shale.

In general, the clay beds are lenticular and nearly horizontal in nature. However, in certain areas the attitude of the clay horizon may be dependent on the basement complex surface upon which it rests and may dip or plunge accordingly.

Cement and Aggregates

Measurement of Cement Kiln Shell Temperatures by *R. E. Boehler*—This paper describes experiences in measuring cement kiln shell temperatures with calibrated melting point crayons, paints with color sensitive pigments, aluminum paints, metal stem thermometers, and radiation pyrometers. Work with the radiation pyrometers showed that this method was greatly superior to the others enumerated. The development of a traveling radiation pyrometer for either continuous or intermittent scanning is described. **59H56.**

MINERALS BENEFICIATION DIVISION

Crushing and Grinding

Crushing Practice at Reserve Mining Company Operations by *A. S. Henderson*, *E. M. Furness*, and *F. E. McIntire*—Mine run is crushed at Reserve in two stages of gyratory crushers at the mine, loaded into railroad cars and sent to the E. W. Davis Works for further crushing in two stages of short head cone crushers. Many factors must be considered and controlled to produce the necessary tonnage at the proper size for the subsequent grinding and concentration operations.

This paper will discuss the following factors and their effect on the plants: 1) the method of product control for each crushing stage and the effect of these controls on the ultimate product; 2) the method of operation of both plants in respect to manpower, instrumentation, and maintenance; and 3) the effect of the noncrusher factors, such as blasting in the pit, screening, and dust collecting. **59B63.**

Effect of Thermal Treatments on Grindability by *F. M. Stephens, Jr.*, and *A. L. Wesner*—Several investigations over a 15-year period have been made of the effects of thermal treatments on the subsequent grindability of specific ores. A more detailed discussion in this paper covers the correlation between 1) types of thermal treatments, 2) physical properties which are responsible for increased grindability caused by thermal heating, and 3) experimental results of thermal treatment followed by grinding. Although significant changes in grindability can be achieved by controlled heating systems, heat treatment cannot be assumed to be an economic method for reducing grinding costs except in specialized cases. However, in properly designed elevated temperature systems, a bonus in the form of reduced grinding costs can sometimes be obtained. **59B44.**

Confirmation of the Third Theory by *Fred C. Bond*—Extensive evidence is presented that an equal amount of work input will produce an equal new crack length in ores ground to different product sizes. This confirms the Third Theory statement that useful work input is inversely proportional to the square root of the product particle diameter, and directly proportional to the square root of the new surface area produced.

A new method of calculating crack lengths and surface areas from Third Theory size distribution plots is described, using the new grind limit of $1/10\mu$. The crack length can be determined graphically from the size distribution plots.

Work index variations result from breakage heterogeneities at specific particle sizes. They do not change the crack length produced, and do not affect the validity of the Third Theory. **59B32.**

Chemical Process—Uranium

Joint Session with Extractive Metallurgy Div. of The Metallurgical Soc.

Kinetic Study of the Dissolution of UO_2 in Sulfuric Acid by *Theron L. Mackay* and *Milton E. Wadsworth*—Sintered UO_2 samples were leached in sulfuric acid solutions of various concentrations. A pressurized system was used so that it was possible to investigate the kinetics of the reaction to 270°C with oxygen overpressures as high as 900 psi. The rate was observed to be a function of the concentration of hydrogen ions and directly proportional to the partial pressure of oxygen. Evidences are presented which indicate that a UO_2 surface site reacts with a molecule of water to form a hydroxyl complex which in turn can dissociate with the characteristics of a weak acid. A rate-determining step has been proposed which involves the reaction between an oxygen molecule and the hydroxyl complex on the surface of UO_2. **59B42.**

Working the Kinks Out of Homestake-New Mexico Partners Mill by *Clyde N. Garman*—First group to obtain a contract with the AEC to produce uranium concentrate from Ambrosia Lake ores, the partners are also the first to put a mill into operation, startup dates being October 1957 for the sampling plant and February 1958 for the actual ball mill operation. Details of plant flowsheet, equipment, and operating procedures are given. Each phase of the operation is discussed in respect to some of the problems encountered—and solutions to them—during the initial months in production. **59B54.**

Mill Design

Some Design Aspects of Large Uranium Mills (with specific reference to the Rio Tinto group of uranium producers in the Elliot Lake area) by *D. J. McParland*—This paper will deal generally with several basic aspects of mill design problems, with special reference to the seven concentrators of the Rio Tinto group presently milling approximately 20,000 tpd in the Elliot Lake area. The paper will cover briefly site selection and alternative forms of building construction with a comparison of steel frame structures vs glue laminated wood beams and will include a few brief points on selection of sheeting and building cover.

Mill electrical distribution systems will be discussed with reference to the comparison of 2300 vs 4160 v distribution. Adequate lighting requirements and various lighting alternatives will also be covered.

Some discussion will take place on the general economics and the application of large hp drive selection, including wound rotor motors, high torque induction motors, fluid drive couplings and synchronous motors, as applied to heavy mill equipment. Some comments will be made on the general designs of tailings disposal systems in the area, line selection, and the building of tails disposal at Milliken Lake mine. This installation handles 3500 tpd at heads up to 500 ft in one

four-stage series pumping arrangement. This installation, which eliminated costly booster stations, is believed to be unique. There were many design and control problems involved in both the selection of pumps, materials of construction, and the piping layout. **59B81.**

Semidome-Shaped Buildings for Bulk Storage by *Edward E. Ives* and *William L. Payne*—Four semidome shaped buildings have been designed and constructed for bulk storage of potash product. The size of the buildings was determined after analyzing the anticipated market demand, the cost per ton of storage, and the required flexibility of handling multiple products. A building of 20,000 cu yards capacity was selected.

The buildings were constructed of laminated timber beams with protected metal sheeting. A design was developed which allowed the buildings to be partially preassembled and sheeted prior to erection. A labor savings of approximately 30 pct was thus realized, even though the buildings were erected during extreme winter conditions.

The total cost for these buildings including excavation, concrete, structure, and sheeting approximately $5 per cu yard of storage capacity. **59B13.**

MINING AND EXPLORATION DIVISION

Geochemical Techniques

Fluorescent X-Ray Spectrographic Analysis in Geochemical Prospecting by *M. L. Salmon* and *H. E. Hawkes*—Analysis of samples collected in geochemical prospecting surveys calls for a high degree of economy and speed as well as adequate sensitivity and precision. Most geochemical surveys in North America have been serviced by the rapid methods of colorimetric analysis developed in the laboratories of the U. S. Geological Survey. These methods are capable of high productivity for samples requiring only a simple acid treatment. High productivity is not possible, however, where fluxing or ashing the samples is necessary.

Fluorescent X-ray spectrographic analysis provides a method of determining the individual concentrations of several elements in organic or inorganic and solid or liquid samples without destruction of the sample. This reduces the analytical processing of the samples to three steps: 1) sieving or pulverizing solid samples, 2) loading into individually sealed cartridges, and 3) X-ray spectrographic analysis by bombardment of the samples with a high energy X-ray beam and measurement of the intensity of the characteristic fluorescent X-ray of the element. The intensity of the fluorescent X-ray from the element is proportional to the concentration of the element in the bombarded sample. A continuous chart recording of the intensities (concentrations) for a sequence of samples provides a direct indication of relative concentrations. The chart can be obtained for about 30¢ per sample on a routine basis. Special modifications of the instrumental procedure make it possible to achieve a detection limit of about 10 ppm for copper and zinc. This is adequate for most cases.

An application of this procedure to the analysis of peat muck overlying a sulfide deposit in eastern Canada is described.

Trace Elements in Pyrite from the Bingham District, Utah by *William Parry, John Brooke,* and *M. P. Nackowski*—In 1957 the trace element content was investigated of 75 pyrite samples from two sections of a mine in the Bingham district, Bingham, Utah. The pyrite samples were analyzed spectrochemically. Trace elements were identified and variations in their concentration were related to distance from nearby orebodies.

Pyrite was sampled on three levels in the first section near one particular ore shoot, and pyrite was sampled on two levels near one ore zone in the second section. The samples were analyzed with a 1.5 m 24,000 line per in. Abney mount grating spectrograph. Special lines of iron were used as internal standards, and analytic data are presented as log intensity ratios of internal standard line to analysis line of the trace element. Precision of the analytic method stated as percent standard deviation varied from 12 to about 40 pct for different trace constituents.

The pyrite from the first section was analyzed semiquantitatively for copper, lead, and arsenic. Elements analyzed semiquantitatively in the second section were silver, lead, copper, indium, and rhodium. Other trace elements found were: gold, calcium, cobalt, copper, iron, manganese, molybdenum, lead, arsenic, indium, aluminum, and silicon.

In the first section both lead and copper increase slightly as ore is approached. Arsenic concentrations are erratic. No correlation was found between the concentrations of silver, lead, copper, indium, rhodium, and distance from ore in the second section.

Mineragraphic examination of samples revealed two textural varieties of pyrite. However, no correlation was recognized between these textural varieties and their trace element content.

Reconnaissance Exploration by Analysis of Heavy Mineral Concentrates by *Paul K. Theobald, Jr.,* and *Charles E. Thompson*—Gold-panning techniques combined with rapid field-chemical analyses of the concentrates provides a reliable method of regional reconnaissance for many metallic elements. Modern stream gravels provide a composite sample of the drainage basin; where contamination by artificially introduced metals or minerals is suspected, terrace gravels may be used as a supplement. Iron minerals of rocks near mineral deposits are enriched in metallic elements such as copper and zinc that may substitute for iron. These metallic elements may be sought by analysis of magnetite, which is universally distributed and may be easily separated from panned concentrates with a hand magnet. When the metallic element sought and its ore minerals are nonmagnetic, analysis of the magnetite avoids contamination. Many metallic elements form resistant, nonmagnetic minerals that may be sought by analysis of the nonmagnetic fraction of the concentrates.

Magnetic and nonmagnetic fractions of concentrates panned from Clear Creek in the Front Range of Colorado have been analyzed by rapid, field-chemical methods for zinc and tungsten respectively. In Clear Creek, values for both metals are 10 and 100-fold higher than in adjacent streams. High zinc values outline the zinc-rich part of the mineral belt in the southwestern part of the drainage basin. The tungsten is in wolframite from a deposit near Red Mountain at the west edge of the drainage basin and in scheelite in isolated small pockets in the crystalline rocks. The anomalous values are evident at the mouth of Clear Creek, more than 20 miles from the source rocks.

Soil Sampling as a Guide to Ore in the Copper Belt of Vermont by *Frank C. Canney*—Geochemical prospecting experiments in the copper belt of Vermont indicate that soil sampling can be used successfully to prospect for copper in areas that were subjected to continental glaciation.

The ore deposits in the copper belt area are covered by as much as 10 ft of glacial till. A brown podzolic soil profile is developed on the till.

Detailed studies were made over the covered ore zone of the Elizabeth mine, where the rocks contain pyrrhotite, and locally sufficient chalcopyrite to constitute ore. Soil samples were collected from the B soil horizon and sieved to −100 mesh; the fines were used for analysis. All samples were analyzed for total copper by a biquinoline field method, and many samples were analyzed for readily extractable copper.

Strong copper anomalies with peak copper values as high as 800 ppm were found over the ore zone. Background values are from 20 to 40 ppm. The anomalies are asymmetrical in shape with the skewed side pointing in the direction of glacial movement; the peaks, however, are located directly over the ore zone.

The dispersion pattern of readily extractable copper is better defined than that of total copper, although either pattern is adequate to reveal the position of the ore zone.

Comparison of Plant and Soil Prospecting for Nickel by *Charles P. Miller*—The results from plant and soil sampling of two nickel deposits are reported and guides for geochemical prospecting for nickel are outlined. A nickel-rich lateritic serpentine deposit in southeastern Oregon and a nickel sulfide prospect in the Stillwater complex in south-central Montana are the two deposits compared.

The nickel content in plants excellently outlined the nickel-rich area at the Oregon locality and possible ore zones within the general nickel-rich area. However, plant sampling was not successful at the Montana locality even though the nickel content in soil was 6000 ppm, the average about 3000 ppm, and the background about 500 ppm. In the Stillwater complex, the nickel content in soil successfully distinguished a nickel-rich norite zone, a peridotite zone, and areas of possible ore grade within the norite.

Sufficient nickel in soil in a form soluble to plants is required before plant prospecting is feasible. It is suggested that about 150 ppm nickel as determined by an acetate-buffer extraction is necessary before plant prospecting is feasible.

Soil sampling is applicable to both these types of nickel deposits, whereas plant sampling is best used in prospecting for deeply weathered lateritic deposits. When the nickel content in soil over lateritic deposits exceeds 3000 ppm, and over ultrabasic sulfide deposits exceeds 500 to 1000 ppm, possible ore zones are suggested. Each area, however, must always be studies in relation to surrounding rocks. **59L40.**

Underground Mining I

Mining at Gaspe Copper by *W. G. Brissenden* and *J. A. Hall*—Mine is situated in heart of Gaspe Peninsula—large tonnage low grade orebody: 20,000,000 tons of 2 pct Cu, 45,000,000 tons of 1 pct Cu. The ore occurs in highly silicified limestone beds as quartzite or skarn. Three major occurrences are presently being worked, one as open pit operation, two as underground operations. The open pit operation is not yet properly equipped, but produces 20,000 tons of ore and smelter flux per month. The two underground operations are trackless. *B* Zone ore averages 30 ft thick, 19° dip. Headings are full face, 45 ft wide, roof bolted and taken on room and pillar pattern. *C* Zone ore averages 70 ft thick, but is 100 to 110 ft thick over wide areas. Overcut (top) headings are taken as in *B* Zone. Benching with horizontal holes follows. *B* and *C* Zone production is 155,000 tons per month.

Equipment used consists of Rogers vertical drill mast jumbos, booms are mounted on Koehring Dumptors, Cat tractors, etc., 1½ and 2½ cu yards electrical shovels, Mack trucks, Koehring Dumptors, Trump Ciraffe scaling rigs (40, 50, 75, and 110 ft), etc. Development headings from operating areas use Joy loaders, Eimco 630's, Eimco 150's shuttle cars, small trucks, and forced ventilation. Development ore amounts to 20,000 tons per month.

Ore is dumped in the ore zones into ore pass systems, passed through primary and secondary crushers located underground, and hoisted by a 19°, 2300 ft long belt conveyor to surface.

Plant includes concentrator, smelter, and those extensive repair and overhaul facilities required by remote location. Anodes produced are trucked 65 miles. Company has provided a modern townsite. **59AU64.**

Long Hole Drilling as an Aid to Mining and Development Work at United Park City Mines Co. by *G. W. De LaMare*—This paper summarizes the experience and the results that have been attained in four years of long hole drilling as applied to exploration, geological, and mining problems at United Park City Mines Co., Park City, Utah.

The following subjects are covered briefly: 1) a general geological picture of the Park City District explaining the complexities of the limestone-replacement ore bodies and the difficulties encountered in finding and mining these ore bodies economically using conventional means of exploration and development work, such as drifts, raises, X-cuts, and diamond drills; 2) the development of a long hole drilling program as a successful and economical supplement to conventional exploration methods, a) using long hole drills as an efficient and economical tool in conjunction with detailed geological work in finding irregular and scattered ore bodies and in obtaining geological information (Specific examples are cited and through illustrations) and b) using long hole drills as an aid to mining operations (Specific examples are cited and amplified through use of illustrations); 3) organizational set-up of long hole drill program and equipment used in program; 4) advantages and disadvantages of long hole drilling; and 5) conclusions are reached. **59AU75.**

Ground Movement and Subsidence from Block Caving at Miami Mine, Miami, Ariz. by *James Bishop Fletcher*—This is a compilation of observed ground movement and subsidence data from the mining of 146,000,000 tons over a period of 48 years.

In an endeavor to duplicate the action that takes place in block caving, a model experiment was performed. The results of this experiment are shown in a series of illustrations. This experiment visually verifies the conclusions drawn as to ground movement and subsidence in block caving: 1) that the ground caves essentially vertically above a stope, 2) that the vertical tension cracks surrounding a caved block do not represent shear planes extending from the surface to the mining level, 3) that ground movement does occur outside the caved area and the distance that this movement occurs varies with the strength of the rock, 4) that a line drawn from the mining level to the escarpment does not represent a zone of broken ground, and 5) dilution from capping is an inherent characteristic in the mining by block caving but can be largely controlled by the proper drawn supervision. **59AU27.**

Geophysical Techniques

AFMAG—A New Airborne Electrical Prospecting Method by *S. H. Ward*—Since the advent of the first airborne electromagnetic system, it has been evident that such systems were inherently limited to shallow depths of exploration of the order of 100 to 200 ft. Hence in 1948 the author and his associates commenced a study of the feasibility of applying natural audio frequency magnetic fields to investigation of the electrical properties of the subsurface in order to provide a system capable of overcoming this limitation. This research culminated, in the summer of 1958, in the development of a new airborne prospecting device—AFMAG. This device has detected surface massive sulfide bodies while flown at heights as great as 3000 ft. Hence, by inference, it is deduced that it could find similar sulfide bodies if they were buried 2500 ft below the surface and the aircraft flown at 500 ft. Thus a considerable improvement over conventional airborne electromagnetic systems is obtainable with AFMAG. Airborne exploration in mountainous terrain involving deep valley fill now becomes possible.

Examples are presented of the results of actual airborne AFMAG test surveys over known deposits of massive sulfide mineralization. Interpretation of the data is discussed with particular reference to the knowledge of size, dip, depth, depth extent, and conductivity of causative bodies as deduced from the flight records.

The possibility of mapping major geologic structures, for both mining and oil exploration purposes, is discussed with the aid of examples of airborne AFMAG data.

Uses of Induced Polarization as a Geophysical Tool by *P. G. Hallof*—Induced polarization as a geophysical measurement refers to the blocking action or polarization of metallic or electronic conductors in a medium of ionic solution conduction.

This electrochemical phenomenon occurs wherever electrical current is passed through a block of ground that contains metallic minerals such as base metal sulfides. The polarization can be observed at the surface as a decay in the measured voltage when a dc current is turned off or by observing the frequency dependence of the ground resistivity.

Experience has shown that the IP measurement is much more sensitive to sulfide content than other geophysical measurements, such as EM and resistivity, which depend upon the conductivity contrast in the ground. Sulfide mineralization as low as 1 to 2 pct can be located from the surface if it is present in sufficient volume.

Because of its special properties, the IP effect can be useful in several ways in the search for base metals. The most useful include: 1) location of disseminated sulfide deposits of the Porphyry copper type, 2) location under certain conditions of massive sulfide bodies that cannot be located by EM methods, and 3) evaluation of poorly conductive EM anomalies that are suspected of being caused by ionic conductors such as overburden of water-filled shears.

The usefulness of induced polarization measurements in these situations can be demonstrated by actual field results.

Some Applications of Seismic Bedrock Investigations in Ore Prospecting by *J. C. Stam*—A portable refraction seismograph has been developed by Geophysical Specialties Co. and has been used for more than a year by Hunting Technical and Exploration Services Ltd. A hammer is used to initiate an impulse and the travel time is obtained directly in milliseconds. The instrument with hammer and connecting cables weighs 40 lb and is easily operated by two men. Depth to bedrock determinations can be carried out in 10 to 30 min, depending on the depth. Calculations can be carried out directly in field within a few minutes. The practical limit for hammer operation is about 50 ft but by using explosives this range can be extended to about 150 ft. The main use of this instrument is for road construction, dam-site investigations, and other engineering problems. However, easy operation and low cost make it suitable for some mining problems. Examples are given to illustrate its use in this field.

One example shows how the apparatus helped in locating buried pre-glacial river channels in Quebec which are potential sources of alluvial gold.

Another example shows how the instrument was used in a geological research program. Here an exploration drilling program of an area entirely covered by overburden was set up after the results of a seismic survey.

A further example shows how the instrument can be used to find the best spot for drilling an EM anomaly at lowest costs.

Other examples indicate that the instrument can be used in solving numerous other problems connected with prospecting and developing of ore bodies. **59L38.**

The Application of the Methods of Operations Research to Prospecting by *Robert J. Uffen*—The principles and methods of operations research are reviewed and their applicability to prospecting is demonstrated with examples from search and hunt problems. It is shown how Agocs and Slichter's (references given in paper) work may be extended to include several methods of exploration, to evaluate the efficiency of the prospecting of a property, and the effect of prospecting plans of sudden economic changes.

The Canadian Aero/Newmont Helicopter-Borne EM System by *R. H. Pemberton*—The paper initially touches upon the history of the development of airborne EM systems. Mention is made of the basic theory of the EM method in such a way that it can be understood by all exploration personnel. The recording apparatus is discussed with particular emphasis being placed on the advantages of recording simultaneously the EM, magnetic, and radioactive fields. The qualitative and quanitative evaluations of the measured fields is discussed in terms of their probable geological significance. A number of illustrations of the results obtained over a number of massive sulfides and other conductors will be shown to illustrate the validity of the text. **59L39.**

Measurement of Physical Properties of Iron Formation and Associated Rocks in the Lake Superior Region by *C. J. Zablocki*—Electrical resistivity, magnetic susceptibility, and gamma-ray intensity measurements of iron formation and associated rocks have been in the Cuyuna and Mesabi iron ranges of Minnesota, the Gogebic iron range of Wisconsin, and the Iron River area of Michigan. The measurements have been made in drill holes and on core samples in the laboratory. In addition to providing information on physical properties for surface geophysical methods, the inhole measurements are valuable as a supplement to regular core analysis and description.

Electrical resistivity of the iron formations varies widely. This variance is apparently related to the porosity and type of iron mineral present. Iron carbonate and iron silicate have high resistivity (400 to 1000 ohmmeters). Hematite, in the enriched iron ores of the Cuyuna and Mesabi ranges, has moderately low resistivity (20 to 100 ohmmeters) because of higher porosity. In the Iron River area similar relationships are found.

The taconites of the western Gogebic range have extremely low resistivity (less than one ohmmeter) in the chert-magnetite-specularite parts of the iron formation. This is true because, here, electrical conduction is through metallic mineral grains rather than through pore waters. Associated silicate-magnetite rocks have high resistivity (500 to 1000 ohmmeters). In general, the rocks adjacent to the iron formation have much higher resistivity (1000 to 5000 ohmmeters) than the rocks in the iron formation; an exception is the conductive graphitic slate in the Iron River-Crystal Falls district.

Magnetic susceptibility measurements, both in continuous inhole logs and laboratory measurements, correlate with the magnetite content.

The high radioactive intensity of slates below the iron formations is revealed by gamma-ray logs.

Underground Mining II

Algom Nordic—Development to Production by *Murray W. Airth* and *E. R. Olson*—The Nordic mine of Algom Uranium Mines Ltd. is located four miles to the east of the town of Elliot Lake, the uranium capital of the world, and the center of the Algoma uranium mining district. Ore reserves in this amazing mining camp have been conservatively estimated to contain 300,000,000 tons of material containing 2 lb U_3O_8 per ton.

The Nordic mine lies on what is known as the limb of the Quirke Lake trough, a synclinal depression which contains all the mines in the district, save one. When diamond drilling was suspended on the Nordic property in January 1955, an orebody of very large proportions had been established within its boundaries. Shaft sinking, started in January 1955, was completed in December and normal underground development got underway immediately.

Plant construction and mine development proceeded on a round-the-clock basis throughout the year 1956 and the concentrator was essentially complete by the year end. The first projection was achieved in January 1957 and by this time nearly 150,000 tons of ore grading 2.70 lb U_3O_8 has been stockpiled on surface in readiness. Development and stoping continued throughout 1957 and the plant achieved maximum operating capacity by April of that year. Design capacity is 3000 tpd but this rate is being exceeded.

Development underground was carried out using trackless haulage methods. This involved the use underground of diesel powered shuttle cars with a carrying capacity of 14 tons, diesel full-dozers, diesel and air-powered mobile automatic drill jumbos, 30 and 50 hp electric slushers and mobile service vehicles. An incline at −14° from surface permitted the entry into the mine of the large mobile units and allowed them to be brought to surface for major overhaul.

When ground conditions permitted, mining was done by mobile drill jumbos in the stopes involving large blasts and movement of much by bulldozers. Where ground conditions didn't permit this type of mining, airleg machines broke smaller amounts of ore which were scraped to waiting shuttle cars. All run of mine ore is crushed underground in a 36x48-in. jaw crusher and hoisted to surface in seven-ton capacity skips.

At this time (Fall 1958) the mine is hoisting 100,000 tons of ore monthly on a six-day week basis; 1035 people are directly employed, of whom 375 work underground. **59AU71.**

Pillar Extraction at the Mi Vida Mine by *Virgil A. Bilyeu* and *Theodore J. Barrett*—Brief description is given of physical characteristics of Mi Vida ore body, strike, dip, length, width and thickness, and ore limits of main ore body and outlying ore pods. Development of orebody includes three phases: early blocking out of irregular pillars, systematic blocking of pillars on 100 ft centers with rooms at angle of 45° to strike and dip, and systematic blocking of pillars on 100 ft centers along strike and 40 ft centers up and down the dip. Extraction methods include extraction of 20x80-ft pillars retreating along strike and extraction of 80x80-ft pillars. Recovery of lost pillar stumps includes removing cave from stump, recovering stump from beneath by driving under cave area, and driving under pre-lain timbers to pillar stump. Extraction conclusions and results of pillar extraction to date are included.

Mining Problems and Developments at Ambrosia Lake, New Mexico by *Donald T. Delicate*—The Ambrosia Lake district located about 20 miles north of Grants, N. M., promises to be the greatest uranium producing area in the U. S. It is situated in a broad semi-arid valley on the northwest flank of the Zuni uplift. Mines of the district will supply ore for four mills with a total nominal capacity of 7275 tpd, all of which will be produced from underground operations.

Underground development of orebodies occurring in relatively flat lying sandstone and shale beds of the Morrison formation is proceeding by various methods. Approximately 20 mines are in various stages of development. Access to the ore horizon is by vertical shafts at all but one of the operations.

Development of the ore bodies which range in thickness from less than 1 to 100 ft is primarily by room and pillar methods on one or more horizons. Large trackless equipment and conventional small mining equipment are used in the development and mining work.

Major problems have confronted the operators in the Ambrosia Lake district, most important of which is drainage and ore handling. Operators have experienced considerable difficulty in pumping sand-laden water from the saturated sedimentary beds and handling fine sloppy muck.

Many methods of ground support have been used to support relatively weak sandstone and shale beds.

Development of equipment suitable for underground use under adverse conditions has been an important problem.

Selection of mining methods suitable for extracting thick irregular orebodies in weak sediments has been a difficult problem. In several mines orebodies or lenses occur in great thickness and often lie one over the other with interbedded layers of waste.

Underground Storage for Hydrocarbon Fluids by *R. L. Loofbourow*—Storage discussed is in direct contact with rock. Except in entrances, no lining is used. Investment by natural gas and petroleum industries is about $450 million, some 85 pct of it for storing natural gas.

Underground gas storage capacity totals about 2 trillion standard cu ft, roughly equal to 28 pct of the gas marketed in 1957. This would fill some 2 million of the familiar large low-pressure gas holders.

Underground storage capacity for liquified propane and butane (LPG) is 42 million barrels, roughly 26 pct of the volume marketed in 1957. To hold this liquified gas would require some 50 thousand of the largest pressure vessels seen in the yards of distributors, or 210 thousand pressure tank cars, ten times the number in this service.

Supplies are accumulated in storage to meet heavily seasonal demands. Storage near markets facilitates transportation as well as production and protects against interruption. It has been estimated that without under-

ground storage, the cost of natural gas on the east coast would increase 40 pct.

Four types of underground storage are in use. Rock requirements for each are distinct —and exacting. The most recent is storage in specially built excavations which are adaptable to a wide range of products, can be built where other types cannot, and have certain intrinsic advantages. Capacity of excavated storage is least, but it was doubled by work completed in 1958. Projects under construction will increase this capacity considerably, and work contemplated could multiply it several times again. **59AU82.**

Health, Safety, and Personnel

A Campaign for the Elimination of Accidents at the Lavender Pit, Copper Queen Branch, Phelps Dodge Corp., Bisbee, Ariz. by *W. K. Pincook*—In the campaign to eliminate accidents at the Lavender Pit, it was recognized that both management and the working force must accept their responsibilities wholeheartedly and exert an honest effort to fulfill their obligations to the fundamental principles of an effective safety program.

As to policy, the owners and management must honestly believe that the *safe way* is the cheapest and most productive way, and the policy of the company shall be: 1) to declare its sincere desire to avoid accidents; 2) to initiate a sound safety program with policies, procedures, and staff necessary to make it effective; 3) to provide all necessary physical safeguarding; 4) to develop an effective training program both for supervisors and the working force; and 5) to exert continuing vigilance enforcing the program.

Also as to policy, the employes must be depended upon to cooperate wholeheartedly with the sincere declaration of the company by: 1) manifesting their desire to avoid accidents, 2) recognizing their individual responsibility for accidents elimination, 3) participating earnestly and using all physical safeguards and equipment, 4) developing and constantly practicing the maximum degree of individual safety consciousness, and 5) complying individually and collectively in the enforcement and continuous improvement of the program.

The general safety program includes: 1) unit safety meetings and bosses and supervisor meetings, 2) participation of employes by elected secretaries, 3) plant inspections, 4) investigation and reporting of accidents, 5) disciplinary measures and standards, 6) codes of safe operating procedures, 7) first aid and job safety training, 8) visual training with sound films, and 9) monthly training classes for foremen and bosses.

The motivating force for a successful program of necessity has to come from management while the results depend entirely upon the understanding and cooperation of the supervisory force and the working force.

Symposium—Exploration Problems

The symposium will be handled as a panel discussion with various questions proposed for consideration. The participants and their particular subjects are: management, *James Boyd* and *C. White;* government, *C. Anderson* and *J. Harrison;* geology, *H. Schmitt* and *C. P. Jenney;* geophysics, *G. Rogers* and *H. Seigel;* and geochemistry, *H. E. Hawkes, Jr.* and *J. Riddell.*

Questions for the panel will cover a wide area of the exploration field—from management, finance, and organizational set-up and procedure to theoretical aspects, current practices, and the *public relations* aspects of exploration.

Copies of the questions to be covered will be distributed at the session.

Open Pit I—Drilling and Blasting

Expansion and Development of Transportation System in Chuquicamata by *Robert Laurich*—Of the many contributing factors to optimum mine production, an efficient transportation system is one of the most important. In recent years an increase in production demand has necessitated the improvement and expansion of the transportation system.

The Chuquicamata pit was opened in 1915, with steam locomotives and steam shovels brought down from the Panama Canal excavation project. During the period 1927 to 1935, electric locomotives were purchased. Electric locomotives with diesel auxiliary power for service in the loading areas were purchased in 1950. With the development of benches below crushing yard level, adverse grade haulage was introduced to the Chuqui pit. Large diesel electric locomotives were brought into the mine in the period 1953 to 1957, for the adverse grade haulage.

Stripping of waste in the upper levels of the mine by truck haulage began in 1951. At the present time 65 pct of the waste removed daily from the mine is moved by trucks.

The standard of main line and bench track has been improved to accommodate the heavier traffic flow. Expansion of the railroad system has progressed with the development of new benches. Construction of a new main line approach to the sulfide crushers will be terminated shortly. This project was initiated to alleviate the congestion of traffic flow at the switching yard at the south entrance of the mine.

Plans are being made to carry on a deep pit mining program. With the termination of open pit mining in Chuquicamata, block caving of the remaining ore reserves will follow. **59AO49.**

Drilling Methods and Equipment at New Cornelia Open Pit Mine by *John Edmund O'Neill*—Rock drilling operations of the New Cornelia open pit mine of Phelps Dodge Corp. at Ajo, Ariz., are discussed.

A brief description of the open pit mine and operations is given and, more specifically, the different rock types and the variable physical characteristics of the rocks which have led to the development of the drilling techniques used at Ajo are described.

The application of the various drills is discussed, and a short summary, from previously published articles, on drill performances and efficiencies of churn drills and heavy percussion air drills at Ajo, is noted for comparative purposes. The introduction of large rotary drills and the conversion of quarry drills to down-the-hole hammer drills concerns the more recent changes in drilling equipment.

Present operation and efficiency of drill equipment is described and bit, drill pipe, and other performance data enumerated. The presentation concludes with a short summary of advantages and benefits resulting from recent changes in drilling methods and equipment at Ajo. **59AO79.**

Ammonium Nitrate Blasting Agents by *Louis W. Towle*—Ammonium nitrate treated in various ways with nonexplosive sensitizers has been in use for blasting agents approximately four years. Ammonium nitrate blasting agent costs are low and permit impressive savings when properties permit replacement of fixed explosives. These blasting agents generally have been found satisfactory and safe to use.

During early use of ammonium nitrate blasting agents, the preparation and use of such mixtures were in many cases on a trial and error basis. Properties of such mixtures were not generally agreed upon, which encouraged investigation of explosive properties of such mixtures by interested groups. A discussion of preparation and explosive properties of ammonium nitrate blasting agents is given.

Firing Fertilizer for Fragmentation by *John Ronald Knudson*—Early in 1956, the Cleveland-Cliffs Iron Co. conducted a series of experiments with ammonium nitrate that led to the development of the popular fuel oil and fertilizer blasting system. The impressive reduction in blasting costs made possible by the use of this new agent, coupled with its excellent safety features, prompted the rapid adoption of this mixture for large diameter, dry hole blasting throughout the U. S.

Subsequent investigations on many fronts by mine and quarry operators, explosives manufacturers, and ammonium nitrate suppliers have produced several methods of mixing, charging, and priming prilled ammonium nitrate and oil. In addition, various innovations designed to permit the use of ammonium nitrate in wet holes have been introduced. At present, the most widely accepted water-resistant blasting agents are still those supplied by the established explosives manufacturers. **59AO29.**

Open Pit II—Loading and Haulage

History and Geology of the Berkeley Pit

I. **Introduction** by *Charles G. Goddard, Jr.* —The Butte district has produced over $2,250,000,000 in copper, zinc, manganese, silver, and gold, unprecedented in the mining world. Exhaustion of the gold placers, located in 1864, was followed by Ag-Au mining from many of the vein outcrops. Montana was the leading silver-producing state in the 1880's. Deeper mining disclosed copper occurred in abundance. From this beginning Butte became the greatest copper-producing district in the world. Many independent companies were producing ores, each on a segment of Butte's complex geologic pattern and ultimately giving rise to serious claims of ownership under the Apex Law. Intensive and costly litigation terminated in purchases of various mining interests by the Anaconda Copper Mining Co. During this first period to 1910, 6,600,000,000 lb of copper were produced. At the time of the initiation of the Kelley mine, another 6,600,000,000 lb of copper were added, and at the end of 1957, a total of 14,604,000,000 lb of copper were produced during Butte's 78-year history.

Deep levels continue to show the same type of copper mineralization that was found on high levels. This continuing resource and improvements in mining, mechanization, and efficiency allow Butte to continue as an important producer of mineral wealth. The Berkeley, planned to augment production of the deeper mines and the Kelley block cave mine, was made possible as the result of studies of old geologic records and incomplete sampling data. The existence of a supergene enriched sulfide orebody near enough to surface for open pit mining was proven by underground sampling crosscuts and extensive churn drilling from surface.

II. **Service Facilities for Mobile Equipment at Berkeley Pit Operations** by *Paul M. Young* —This part describes the planning and selection of the necessary service facilities for all of the mobile equipment used in the Berkeley Pit operation.

A list of the mobile equipment necessary for the pit operations is given, as well as a description of the various buildings required to house all of the facilities. The various shop areas are listed along with the tools and equipment for the various service operations. A description of the fuel storage and handling system as well as the lubrication service is included also.

The service facilities provided were such that a good planned preventive maintenance program could be put into effect, and a few brief comments on such a program are included.

Three illustrations are included showing the arrangement of the yard, pump house for fuel, and the main garage and shop building.

III. **Berkeley Pit Crusher and Conveyor System** by *Frank Ralph*—This section of the paper pertaining to the Berkeley Pit operation covers the mechanical rock handling system from truck to railroad car, consisting of truck dumping facilities, a screening and crushing plant, five main conveyor belts, stockpiling equipment, storage bins, and railroad car loading facilities capable of handling 2000 tph of ore.

Some detail concerning the mining and concreting of the 700-ft tunnel necessary to accommodate the main conveyor is discussed as well as various phases and construction problems encountered during erection.

Details of the mechanical, electrical, and structural installations are covered and the sequence of operation and protective interlocking control are explained.

IV. **Layout and Mining of Berkeley Pit** by *Edward O. Bonner*—The introduction to this part covers the following information: start of open pit mining in the Butte district; a description of the methods used to verify the existence of a large low grade orebody; pit design including leach and waste disposal areas; long range planning for the pit; tonnage of ore, leach, and waste material that will be removed from the pit; and past and present production statistics.

Specific information is given about pit estimates; measuring methods; and capacities of Berkeley crushing plant, conveyor, and storage systems under their respective headings.

A detailed description of all of the operations grouped under mining operations completes the paper. Mining operations include drilling, sampling and geologic mapping, blasting, shovel loading, haulage, surfacing and permanent roads, and road and dump maintenance.

Also included with the paper is a six-month summary cost sheet of the pit operations. **59AO50.**

Selection of an Open Pit Haulage Method by *W. N. Matheson*—Due to climatic and terrain factors on the Mesabi Range, selection of haulage systems is particularly important, especially from an economic view. The three major methods now in use on the range —rail, truck, and combination haulage—are discussed in relation to open pit operations. Reasons are given for the choice of one system over another.

For the optimum cost and operational benefits, the following factors must be considered: 1) the quantity, quality, and outline of the orebody; 2) the amount of material to be removed for each haulage method, including stripping; 3) consideration of the waste material intermixed in the orebody and its removal; 4) computation of lift and haul; 5) capital cost for facilities and equipment; 6) operating cost estimates; 7) total costs vs resultant earnings; and 8) same details for each possible alternative. After these elements

have been weighed, such additional problems as safety, future flexibility, available equipment, economic perspective, and relation to overall pattern of company operations must be considered. 59AO36.

Improvements in Loading and Hauling Equipment and Their Effect on Unit Costs by *Charles Scott Davis*—The principal visible improvement of recent years in loading and hauling equipment has been the increase in size. Crawler-type power shovels in 6 to 10-cu yard class are commonplace in large stripping operations. Large shovel capacity called for increased truck payload. Large shovels dogged the capacity of blasthole drilling equipment, calling for ever-increasing drilling speed and efficiency.

The revolution in size is due to several factors:

1) With the ever-increasing labor cost, a demand has developed for greater capacity per manhour and for more hours of availability on each piece of equipment. 2) Improved technology in the mechanical and electrical field of engineering has challenged the profession to create more efficient tools. 3) Operators of equipment come from an increasingly higher educational and intellectual plane so that increased productivity through more intricate tools is not only feasible but meets a challenge of boredom sometimes evident in today's operator.

Economics of the mines being worked has demanded greater efficiency in equipment. Lower grade ores with lesser values are being worked and loading and hauling are inherently among the principal mining costs. For this reason the mine operator/equipment manufacturer team are under constant pressure to whip the lower grade ores/rising fixed and hidden costs team.

As a contractor-operator, great attention is given to the combination of loading and hauling equipment by Utah Construction Co. Equipment of many sizes from many manufacturers is bought and operated. Operating costs are carefully kept and reviewed in relation to operating conditions and in relation to the unit cost of loading and hauling. A result is that small increases, and often decreases, have been noted in these operations in recent years. This is accomplished while operating labor has increased 100 pct. Services and parts, and the equipment itself, have increased greatly in cost, indicating that improvements in equipment and operating technique have advanced at a greater rate than expanded costs. 59AO36.

Replacement of Capital Equipment by *Henry Schwellenbach*—New York Trap Rock Corp. is located on the Hudson River and supplies construction aggregate for the metropolitan New York and New Jersey area. For a number of years capital equipment was replaced only when money was available and equipment no longer serviceable. No particular regard was given to its efficiency or operating and maintenance costs. Several years ago the management felt that a plan was needed. After evaluating several systems an individualized one was evolved from the basic pattern developed by the Machinery and Allied Products Inst.

In essence the system operates in the following manner: A project for study is initiated by any interested individual and then either approved or disapproved for further study by the project committee. If approved, someone is assigned by the committee to make a preliminary study of the advisability of replacement of the capital item or process. If this preliminary study shows that the replacement is of financial benefit, then the project committee will make a detailed financial analysis of the expenditure and will present it to the finance committee with its recommendations.

Exploration Ventures—Case Histories

A Technical Success by *D. J. Salt*—The paper illustrates the successful application of the vertical coil electromagnetic method to locate massive sulfides. Magnetic confirmation was also obtained on the conductors.

Drilling encountered massive sulfides, as predicted, but unfortunately no ore. These massive sulfides provide an excellent proving ground for geophysical equipment designed to locate conductors. Many methods have been and are being tested on these sulfide zones. These test results are also presented.

Methods of analysis of geophysical results could be compared in theory to the actual situation as determined by drilling, with the hope of improving analytical methods.

At the present time studies of the physical properties of the drill core are being contemplated to correlate with the field geophysical data.

Geology and Exploration Developments, Mattagami Area, Northwestern Quebec by *C. P. Jenney*—The Mattagami area is a region of some 2500 square miles underlain by pre-Cambrian rocks favorable for the deposition of mineral deposits but with more than 90 pct of its area masked by 20 to 100 ft of glacial overburden. Although prospected by conventional methods for more than 50 years, no important discoveries were made. Where exposed, bedrock included the typical pre-Cambrian acid to basic lavas with associated sediments including graywacke, quartzites, and slates. Later pre-Cambrian major indikes and other minor instrusive masses of diabase and lamprophyre cut the older rocks.

Commencing with the 1956 field season, the area has undergone one of the most intensive airborne geophysical survey campaigns, with all presently operating systems used by most of the major mining companies active in Canadian exploration.

This airborne geophysical work, followed by detailed ground geophysics and geology, and also by extensive diamond drilling, has greatly expanded geological knowledge of the area and has led to the discovery of one or more major base metal deposits.

The Esperanza Copper Mine—A Case History of Discovery by *Harrison A. Schmitt*—The mineralized area of the Esperanza copper mine and environs comprises about six square miles. This area had been prospected and drilled for a period of at least 50 years and produced some tens of thousands of tons of Pb-Ag and of copper ore largely from fault veins. One old prospecting shaft passed through the edge of the Esperenza orebody, and one churn drillhole of a group used to prospect for porphyry copper ore was drilled 1200 ft from the edge of the present orebody. Other drilling not far beyond the ore was done during searches for copper and molybdenum. The present orebody, discovered in 1955, is a supergene enriched blanket type with a significant hypogene root. It was found by defining a geologic anomaly that closely corresponds to the outline of the ore as finally drilled out. Structural, alternation, and capping criteria were used.

Anaconda Exploration in the Bathurst District of New Brunswick by *C. G. Cheriton*—The paper presents a documentary *case history* of the events leading to the discovery of the Caribou sulfide deposit in the Bathurst District of New Brunswick.

Three large sulfide bodies were known in this district prior to Anaconda's efforts in the area. These concentrations of base metal were observed to occur on the eastern and southern flanks of a large steep-sided irregular domal structure. A thick series of volcanic rocks with interbedded tuffaceous and argillaceous sediments have been deformed in a complex manner and are the host rocks for the sulfide mineralization.

Selected Geological Topics

Joint Session with SEG

Geochemical Study of Pb-Ag-Zn Ore from the Darwin Mine, Inyo County, Calif. by *Wayne E. Hall*—The primary ore from the Darwin mine consists mostly of galena, sphalerite, pyrite, pyrrhotite, and chalcopyrite with smaller amounts of andorite, franckeite, matildite, scheelite, tetrahedrite, and an unknown Pb-Bi-Se sulfosalt. The ore occurs in silicated limestone of Pennsylvanian and Permian age as irregular steep pipelike replacements, bedding replacements, and fissure fillings. Twenty samples of galena and 30 of sphalerite were purified and analyzed. Fine-grained galena in the upper workings of the Essex orebody contains as much as 3 pct Ag, 3 pct Bi, and 2.1 pct Se, but the galena in other orebodies contains much smaller amounts of these constituents. Small amounts of matildite ($AgBiS_2$) have exsolved from the silver and bismuth-rich galena but not in sufficient quantities to account for all of the silver and bismuth. None of the other elements in the galena exceed 0.1 pct as determined by semi-quantitative spectrographic analysis.

The iron content of sphalerite deposited in equilibrium with pyrrhotite is a function of temperature of ore deposition. The indicated temperatures range from 430°C in the deeper replacement orebodies to 180°C in shallow fissure fillings. 59I47.

A geological concept based on reconnaissance field traverses was verified by linears observed on air photos. Combination airborne magnetic and electromagnetic methods were employed in an effort to single out specific target areas. Ground work including line cutting, detailed geological mapping, electromagnetic surveys, and small amounts of soil and water testing, resulted in the refinement of targets for diamond drill tests. A large sulfide mass was discovered in the limbs of a steep plunging synclinal structure located on the north flank of the domal structure.

SOCIETY OF ECONOMIC GEOLOGISTS

For other SEG sessions with SME Divisions, see under IndMD and M&E.

Economic Geology Session

Relation of Magnetic Anomalies to Some Geologic Structures in Northern Minnesota by *Gordon D. Bath*—The magnetic anomalies over simple geologic structures often can be related to the space distributions and the bulk magnetizations of the ferromagnetic minerals that produce the anomalies. In the Mesabi district, where the magnetite-rich beds of the Biwabik iron formation have been explored by drilling, the formation dips gently southward and is underlain by relatively nonmagnetic granites, quartzites, and slates and overlain by nonmagnetic argillites and graywackes. The most important magnetic unit of the central Mesabi range, the lower cherty member with an average grade of 30 pct magnetite by weight, produces magnetic anomalies that must be explained by both induced and remanent bulk magnetizations. The magnetic susceptibility of the iron formation is greatest in the direction along the bedding because of concentrations of magnetite in small irregular layers that are generally parallel to the bedding. The large magnetic anomalies over the metamorphosed upper cherty member of the eastern Mesabi range are explained by a bulk remanent magnetization. In the Duluth area, the basalts at the base of the Duluth gabbro and along the Douglas fault have bulk remanent magnetizations that produce magnetic lows instead of the expected highs. It is concluded that remanent magnetization effects must be considered before using magnetic anomalies to estimate the percentage of magnetite in Minnesota taconites, or to locate the positions of basalt contacts.

Aeromagnetic Effects of Igneous Features in Northern Minnesota by *George M. Schwartz*—A total of about 40,000 square miles of northern Minnesota has been covered by aeromagnetic surveys with flight lines at one-mile intervals. This has been followed by ground work and mathematic analyses of anomalies by the staff of the Geophysics Branch, U. S. Geological Survey.

The bulk magnetization of various igneous rocks has been computed. These data are used as an example of identifying rocks that produce a magnetic anomaly where little is known of the geology.

Rock masses for which data are complete include: a granite batholith, syenite stock, gabbro, granophyre and basaltic flows. Moderate and generally uniform magnetic highs of about 300 gammas occur over rocks of the Giant's Range batholith, 800 over a syenite stock, and 1500+ over a sheetlike mass of granophyre.

Irregular highs and lows are found over thick masses of gabbro and basaltic flows; however, the average field over gabbro is as much as 1000 gammas low as compared with nonmagnetic slates to the rest. In general, effects are uniform over feldspathic gabbro as compared with iron-rich varieties.

An anomaly of 400 gammas of unknown origin is interpreted as resulting from a mass at a depth of 4000 ft. Of all the igneous rock masses investigated in northern Minnesota, only granophyre could produce this consistent magnetic high. It seems unlikely that granophyre exists in that particular area; however, an iron formation buried 4000 ft could produce just such an anomaly.

Structural Environment of the Illinois-Kentucky Fluorspar District by *M. P. Nackowski*—The tectonic structural pattern of the Illinois-Kentucky fluorspar district includes faults, joints or tension fractures, and folds. These structural elements can be referred to three strain systems that developed sequentially from late Paleozoic to late Mesozoic which are considered stages of deformation.

During the first stage of deformation the principal stress directions were oriented as follows: The intermediate principal stress direction was the force of gravity. The maximum principal stress direction was northeast, and the minimum principal stress direction was northwest. The major strain elements referred to this stage include Hicks Dome, the Shawneetown-Rough Creek fault zone, northeast trending tension fractures, and possibly the Ste. Genevieve fault zone.

During the second stage of deformation the maximum principal stress direction was the force of gravity. The minimum principal stress direction was northeast and the intermediate principal stress direction was northwest. The northeasterly trending gra-

bens and tension fractures formed during this interval.

During the third stage of deformation the intermediate principal stress direction was again the force of gravity. The maximum principal stress direction was north 10° to 20° west, and the minimum principal stress direction was north 70° to 80° east. The strain elements related to this stage of deformation are previously developed northeast trending faults and joints, eastwest faults and north 10° to 20° west tension fractures occupied by dikes.

The interval of fluorspar mineralization followed this third stage of deformation. Most of the orebodies are related spatially to the northeasterly trending fractures. Some are related spatially to the east-west trending fractures. This spatial relationship is characteristic of the vein deposits and the bedding replacement deposits alike.

Structures Related to Solution of Borax at Kramer, Calif. by *Ward C. Smith*—Some minor structures in the shales and sandstones that overlie the borax orebody at Kramer, Calif., are the result of subsidence where ground water dissolved and removed borax. The subsidence added local complications to older and larger structures, as can be seen on the walls of the Pacific Coast Borax Co. open pit. Where solution developed a depression of trough in the top of the orebody, as it did along a fault zone now well exposed in the open pit, the younger sedimentary rocks collapsed into local folds that are sharper than those in the underlying borax ore. At several places the hanging wall of the borax orebody contains the collapsed residues of some relatively insoluble detrital layers of borax ore. In general, solution and collapse have obscured the stratigraphic relation of the borax ore to the colemanite-bearing shales of the hanging wall.

The Alhambra Mine, Black Hawk (Bullard's Peak) District, N. M. by *Elliot Gillerman*—The Alhambra Mine is an old silver mine, last worked in the 1890's, that has recently been reopened and rehabilitated. The mineralogy of the deposit is of particular interest, and was the major reason for reopening of the mine. Native silver is the principal ore mineral; pitchblende; nickel and cobalt arsenides, mostly niccolite; skutterudite, probably nickel skutterudite; and rammelsbergite(?) are the other ore minerals. The mineral association is characteristic of the district and is duplicated in relatively few other places.

The rehabilitation has resulted in exposing commercial concentrations of cobalt, nickel, and uranium ore, and high grade silver ore on the upper levels and at the bottom of the shaft. The ore occurs within a steeply dipping fault which traverses pre-Cambrian quartz diorite gneiss. No wall rock replacement is evident, and simple open-space filling appears to account for the ore emplacement.

The ore minerals are in sharply defined ore shoots within carbonate gangue. At a typical exposure in the mine the native silver is concentrated in the central part of the vein and the pitchblende lies in narrow zones along the borders. The nickel and cobalt arsenides lie between the two and are intimately intergrown with native silver.

The success of the present venture may result in the opening of a new nickel, cobalt, and uranium district in the U. S.

A Concept of the Origin of Porphyry Copper Deposits by *C. Wayne Burnham*—The formation of porphyry-type deposits, and perhaps hydrothermal deposits in general, is regarded as a normal extension of magmatic activity under certain conditions. The essential processes in the formation of porphyry copper deposits are visualized as follows:

1) A magma of granitic to intermediate composition that contains water (and other dissolved volatiles) rises into higher levels of the earth's crust and there forms a stock-like mass that undergoes crystallization from the walls inward.

2) Through gravitational effects and the crystallization of anhydrous minerals, water becomes concentrated beneath the crystalline *hood*, producing a residual magma that is nearly or completely saturated with water.

3) The relatively impermeable crystalline *hood*, is fractured, in response either to external forces or to internal forces resulting from the build-up of water vapor pressure, and as a consequence the confining pressure on the residual magma is sharply reduced.

4) Concomitantly, residual magma intrudes the larger fractures, producing characteristic premineralization porphyritic dikes.

5) The violent ebullition of volatiles (the initial hydrothermal fluids) that results from the sharp reduction in confining pressure causes intense local shattering of the crystalling *hood* and adjacent wall rocks, as well as further crystallization of residual magma and consequent ebullition of additional water through *second boiling*.

6) These newly formed hydrothermal fluids permeate the fractured rocks and produce the characteristic micaceous alteration.

7) The metals, extracted from the residual magma and from ferromagnesian minerals already present, are transported largely by diffusion through the fluids and deposited under appropriate P-T-X conditions.

COUNCIL OF ECONOMICS OF AIME

Appraisal of Paley Report

Light Metals and the Paley Report by *Walter L. Rice*—Expansion in all the light metals industries has, in the first five years after the Paley Report, achieved or exceeded the report's expectations. Aluminum is the star performer—it is running far ahead of the projections. U. S. aluminum consumption by 1956 was already above the level inferred for 1960 from Paley Commission projections. Aluminum's rate of growth has averaged about 30 pct faster than the rate anticipated by the report. Although the business recession of 1957-1958 temporarily reduced aluminum demand, all signs at this writing point to an early regaining of the 1956 level, followed by a resumption of growth.

To date the Paley Commission seems to have done an excellent job in foreseeing the growth and problems of the minor light metals such as magnesium, titanium, and zirconium. For aluminum, however, their forecasts of growth may have been too conservative. Whereas they forecast a 1975 aluminum consumption at around 4 to 5 million tons, we now believe it will be more nearly 10,000,000 tons.

Major markets for aluminum are expanding rapidly. Until recently the larger potential industrial consumers, such as automobile manufacturers, were reluctant to design with aluminum until there was adequate capacity to assure large volume consumption. Now that the industry has six large producers engaged in healthy vigorous competition, industrial consumers are assured of dependable suppliers in volumes adequate for important new uses in transportation, construction, and appliances.

Russian raids on the British and European aluminum markets have been obviously timed to disrupt the industry. Soviet economic warfare apparently selected the aluminum industry as its first battleground. Price cutting on a relatively small volume of sales was designed to demoralize the price and discourage healthy growth of aluminum. The industry requires protection not only from Russian raids but also from dumping by friendly producing countries. We are confident that our Government will take appropriate steps to protect legitimate industry from economic warfare and dumping, and that the industry will continue its vigorous growth. 59K31.

Industrial Minerals 1950-1958-1975 With Special Emphasis on Fluorspar by *Raymond B. Ladoo*—Paley Report estimates and projections to 1975 for about nine minerals are compared with actual performance 1950-1957. The fluorspar situation is considered in considerable detail. Conclusions reached were that the Paley Report underestimated world reserves and rates of increase in consumption and production. Paley views on phosphate rock as a major source of fluorine are questioned. New and increased figures for reserves are given, but, without major dependence on the phosphate rock source, known reserves give less than 15 years supply as of today, at present rates of world consumption. Rate of growth of consumption of industrial diamonds was underestimated in the Paley Report. The situations of asbestos, mica, phosphate rock, potash, crystal quartz, and sulfur are briefly considered. 59K23.

Iron and Steel; The Paley Report in Retrospect by *John D. Sullivan*—A comparison of an interpolation of statistical data on the production of ferrous materials and on the supply of iron and steelmaking raw materials with the actual values in 1957 shows that no gross errors in estimation of trends were made in the Paley Report. Differences are of degree rather than kind. There are ample supplies of iron ore, although the tonnage of pellets from the concentration of taconites and jaspers are larger than predicted. Imports from South America are large. This paper shows also the potential new supplies that may be expected from eastern Canada.

Although the Paley Report was pessimistic about the supply of obsolescent scrap, a recent report shows that the potential supply of obsolescent scrap is currently ample and sufficient for domestic needs and reasonable exports, and that it likely will be until 1975. This 1957 report points out, however, that because of the changing nature of steel production the relative amount of heavy melting scrap may be expected to decrease.

Due to technological developments, the coke supply situation appears more favorable than might be inferred from the Paley report.

Although the report was not too concerned about the supply of additive metals, and while there was a shortage—particularly of nickel—a few years ago, the conclusions made appear to be sound, particularly since new supplies of these metals are becoming available.

Certain technological predictions made in the Paley report are treated in detail and some issue is taken over certian estimates of adoption of certain new processes. The role of some of these methods in the present iron and steel industry is discussed.

With regard to Paley report data on non-American industry, this paper covers the possible effect of the European Coal and Steel Community on the U. S. iron and steel industry, and statistics are given on the six Schuman Plan countries. Russia's role in the world picture is considered briefly. Canada is becoming one of the world's leading producers of iron ore. Production there of pig iron and steel likewise is growing. 59K48.

Mineral Economics

Trends in Real Prices of Representative Mineral Commodities 1890-1957 by *Charles W. Merrill*—The price records of seven representative mineral commodities for the period 1890 through 1957 have been compiled and analyzed for significant trends. For purposes of comparison annual average prices have been reduced to two common bases: 1) as quantities of the commodity that could be purchased with the average hourly wage of an industrial worker during the year and 2) the annual average prices of the commodity in terms of dollars deflated to a 1954 base. In terms of these *real* prices, an overall downtrend develops despite an enormous increase in demand during the period. Although many factors have contributed to falling prices in face of rising demand, the most important have been technologic advance and mineral discovery. 59K21.

COUNCIL OF EDUCATION OF AIME

Let's Mechanize Underground Mining by *Roger V. Pierce*—Paper deals with the latest experiments in mechanization of each and every cycle of the basic operations of underground mining. The talk will also discuss other thoughts that are in the formative stage of experimentation, all with the idea of ultimately making footages of 75 ft a day in underground drifting and 25 fpd in shaft sinking.

Problems and Progress in Mineral Dressing by *Norman Weiss*—The problems in the field of minerals beneficiation and the progress we hope for are now wrapped up in one package. In striving for the ultimate in low costs we are deficient in the application of science at one end of the spectrum and in management participation at the other. Both of these deficiencies call for corresponding changes in the education and training of the engineer. A growing trend towards correction is found in the comments of several prominent educators in the field of mineral dressing, and the curricula of four of the leading colleges also assure us of a favorable response to this challenge. Greater emphasis is already noticeable in the subordination of undergraduate studies of the art and practice to the disciplines of basic science and the humanities.

The guidance and the financial support of graduate students are also large parts of the problem. Progress in mineral dressing will depend greatly upon a relatively small group of research scientists and engineers. The means of support must be found and industry should pay the bill. At the graduate level engineering education will lean heavily on good instruction in advanced mathematics and theoretical physics, as well as new areas. Scholars of first rank are needed to teach and inspire these exceptional men.

Some Problems and Some Opportunities in the Industrial Minerals Field by *F. C. Kruger*—Some problems of the burgeoning but as yet immature industrial minerals field are outlined along with some opportunities that await the enterprising mining companies in this field. The education of the geology and mining engineering students to meet this challenge is discussed. A plea for well rounded training of the man rather than the trend toward narrow specialization is made.

CYANAMID

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PROGRESS AND PLANS AFTER TEN YEARS . . .

With this 121st issue MINING ENGINEERING marks its 10th anniversary and enters its eleventh year of publication. The only backward look we will take is to announce that a ten-year cumulative index of technical material is in the works and will be included in the magazine shortly. For those missing Transactions volumes from these years, we suggest you check the box on page 100 of this issue. Next month we will carry a list of back issues still in stock.

Looking ahead, the goal is greater service to Society and Member, with MINING ENGINEERING serving as the mining man's best source, not only of technical information, but of news of his fellow members, of the Society of Mining Engineers of AIME, and of his profession in general.

Steps toward that goal are being taken through better coverage of meeting activity, both in technical and non-technical aspects. Some of the developments are: pre-meeting publicity, detailed meeting programs, abstracts of technical papers, and follow-up stories.

Another important step is the SME Preprint Program. Here again the magazine serves as your best guide to what is available, and when. Gradual extension of this program to major section and regional meetings, begun with the Joint Solid Fuels Conference in the fall of 1958, will be expanded in 1959.

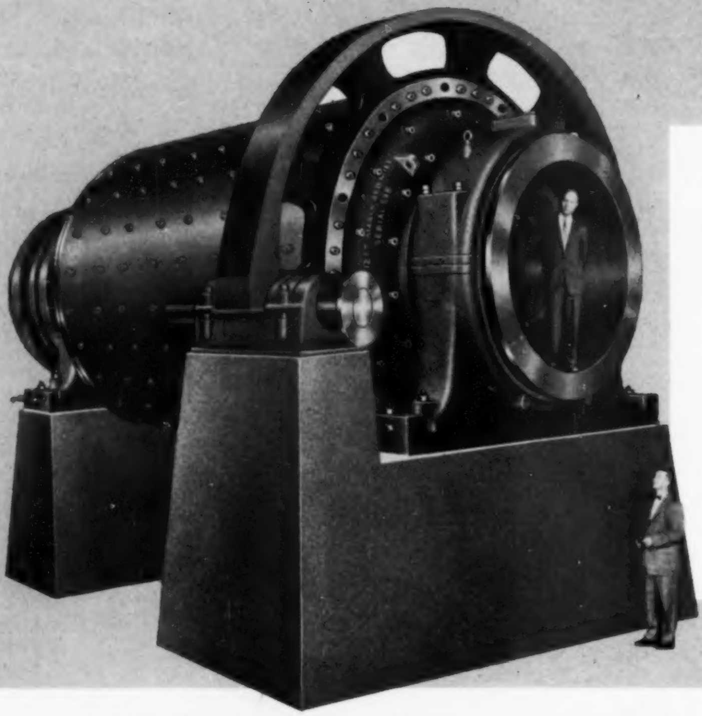
This issue marks the start of a Mineral Information section (page 7) bringing together and extending the coverage of all types of technical data, not only from Society, but from all sources. This, too, will be expanded month by month in the coming year.

Thorough meeting coverage is impossible without the cooperation of the Local Section or meeting committee personnel, and increasing help in this quarter is reflected in the magazine contents. Another group whose support and direction is important is the Editorial Board and publications committees set up under the new SME Bylaws. The names are in the column at the left.

DEPARTMENT OF QUALITY CONTROL . . .

"Seldom saluted, but always working." That is the description of the chairmen, members, and readers of the Divisional Publications committees. The prestige and continuing value of the Transactions offer the best citation for these men who serve the profession by maintaining technical and professional standards in publication.

—*R. A. Beals*



TRENDS IN EARNINGS OF ENGINEERS, 1956 TO 1958

Earnings are climbing . . . A brief on conclusions of the 1958 study, Professional Income of Engineers, by Engineers Joint Council.

Earnings of engineers in the period 1956 to 1958 continued the upward trend observed in the previous survey interval, 1953 to 1956. The overall median (all graduates) was $6500 in 1953, $7750 in 1956 (a 19 pct upstep or about 6.5 pct annually), and $8750 in 1958 (up 13 pct from 1956 or 6.5 pct average yearly). The latter represents an increase from mid-1956 to mid-1958. For this same two-year span the Consumer Price Index rose 1.5 pct and the Average Gross Weekly Earnings for Production (Manufacturing) climbed close to 10 pct.

Median earnings for the major classifications studied are presented in Table I.

The increase in engineering earnings are not distributed equally among the various activity classifications or among the experience levels of the survey. Summary results of the changes of the median lines for the major divisions are presented in Table II. Data in this table are approximations—dollars are rounded to the nearest $50 unit and percentages to the nearest full percentage.

Industry increases closely parallel the overall average increments. Government increases, on the other hand—for both absolute dollars and percentages—are above the averages. This reflects the improvement which governmental agencies have successfully secured in the past two years. A notable example of this was the flat increases granted by Congress in 1958 for Civil Service engineers in the Federal Government. Notable advances have also been made by state and local agencies. The relative rise above the industry increments has not, however, placed government employment in a competitive salary position with industrial employment, but has reduced somewhat the wide margins noted in 1956. Earnings of engineers in government continue to lag most seriously at experience levels beyond 12 years, and beyond this point the 1958 government median line is far below the 1956 industry median line.

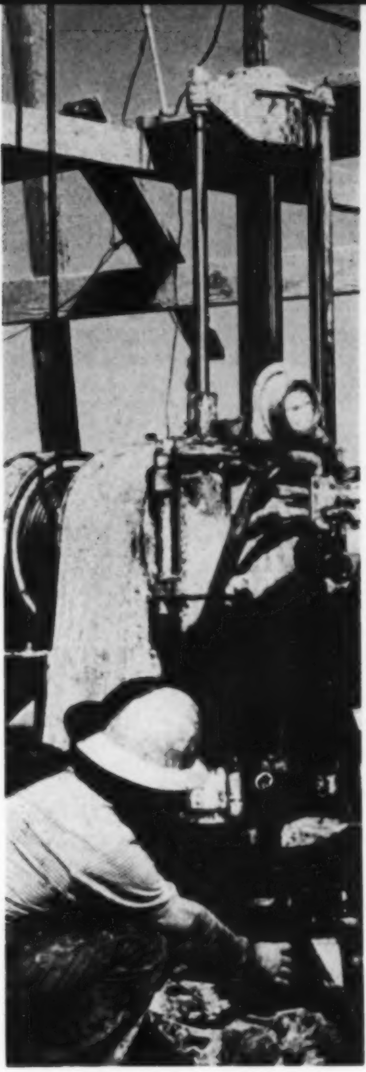
EJC's studies revealed a strong upward trend in earnings in industry between 1953 and 1956. Although industry was particularly affected by the recent recession, this upward trend in earnings continued, although at a slightly reduced rate.

Table I. Median Earnings in 1958 for Engineering Graduates

Year of Entry into Profession	Industry (155,124)	Government (30,028)	Engineering College Teachers (5139)	All Activities Combined (190,810 Engineers)
1958	$5,925	$5,350	$5,600	$5,850
1957	6,175	5,675	5,425	6,125
1956	6,525	6,075	5,700	6,475
1955	6,850	6,400	5,950	6,800
1954	7,050	6,700	6,225	7,000
1953	7,450	6,850	6,400	7,400
1952	7,725	7,075	7,100	7,700
1951	8,125	7,675	7,425	8,050
1950	8,450	7,775	7,500	8,350
1949	8,825	8,050	8,275	8,700
1947 to 48	9,325	8,325	8,625	9,200
1945 to 46	9,675	8,250	8,950	9,450
1940 to 44	10,450	9,050	9,875	10,250
1935 to 39	11,300	9,225	10,650	10,825
1930 to 34	11,350	9,325	10,850	10,675
1925 to 29	11,225	9,575	10,050	11,050
1920 to 24	11,850	9,425	10,650	11,200
1915 to 19	11,000	9,350	9,950	10,675
1914	11,000	9,225	9,175	9,500
Nos. Earning $20,000 and Over	3,125	10	161	3,313
Nos. Earnings Less than $5000	601	735	185	1,530

Table II. Approximate Increases in Earnings from 1956 to 1958

Years from Degree	Industry		Government (All Levels)		College Teachers Total Income		All Activities Combined	
	Dollars	Pct	Dollars	Pct	Dollars	Pct	Dollars	Pct
1	875	16	500	10	350	7	850	16
2	750	13	700	14	350	6	750	13
3	750	12	900	16	600	11	750	12
4	700	10	950	16	600	10	700	10
5	800	12	650	10	400	7	800	12
6	650	9	750	12	850	14	700	10
7	750	10	1,050	16	800	12	750	10
8	700	9	1,000	15	250	3	750	10
9	1,000	12	1,200	17	1,025	14	950	12
10	1,200	15	1,300	19	1,350	19	1,250	17
15	1,000	11	1,400	19	950	11	1,000	11
20	1,100	10	1,400	18	900	9	1,000	10
25	1,100	11	1,100	13	850	9	1,000	10
30	650	6	1,150	15	300	3	700	7
35	950	9	1,000	12	800	8	950	10
40	650	6	1,100	13	1,075	12	1,000	10



DEVELOPMENTS IN CORE-DRILLING TECHNIQUES FOR DEEP MINERALS EXPLORATION

Surface and near-surface drilling targets have received most attention from geologist and geophysicists in past years. Now the trend is toward deeper exploration holes, and that trend should continue, if not accelerate, in the foreseeable future. Progress in geophysical research makes possible the equipment and techniques needed for probing to greater depths.

by JOHN K. HAYES and VERNON READ

Generally speaking, drilling equipment and techniques presently in use are not capable of meeting the complex technical—and economic—requirements of deep core drilling. Drilling to great depths involves increasing risk, time, and money. And it is especially true that costs increase with depth when conventional core drilling methods are used.

Introduction of wire-line drilling techniques has been a great boon to deep core drilling, and is rapidly gaining general acceptance. But, in spite of recent progress, there remains a great need to improve productive drilling time and penetration rates, and still maintain high core recoveries.

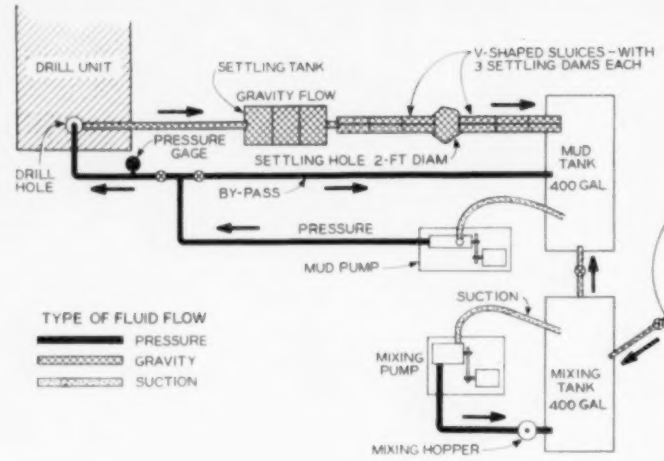
For the past two years, the authors have investigated several oil-drilling techniques, in conjunction with NX conventional and BX wireline coring equipment, to aid in solving deep drilling problems associated with badly fractured ground. These techniques included the use of mud fluids for control of caving and improvement of core recovery, quick-setting gypsum cements for sealing zones of lost circulation, and small explosive charges for backing off stuck drilling tools.

J. K. HAYES and V. READ are, respectively, Supervisor, Raw Materials Exploration and former Raw Materials Engineer, Raw Materials Exploration Div., Columbia Iron Mining Co., U. S. Steel Corp., Provo, Utah.

Use of Mud Fluids

Mud fluids have long been used in oil drilling, and few wells are rotary drilled today without mud and the services of a mud specialist. Some of the mudless holes are drilled dry, using pressurized air or natural gas as the drilling fluid, and in unusual instances water alone may be used. In conventional core drilling mud is often used to penetrate alluvium, but diamond drillers generally revert to plain water or extremely light muds after setting casing to bedrock.

In diamond drilling work using water in ground that caves or loses circulation, core recoveries are frequently poor and bit costs are high, with many bits burned in caved ground. Drilling rates are often exceedingly slow, and much time is wasted drilling cave and attempting to bran-and-cement the hole. It is suggested that a changeover to mud fluids could control caving, thus greatly reducing bit costs and water losses and boosting core recovery percentages.



Schematic of preparation and handling facilities for use of mud in diamond drilling.

To get full value from drilling mud under difficult ground conditions requires particularly close supervision of drill crews, around-the-clock drill operation, and use of the best possible mud pumps to handle the highly viscous fluids.

Leading drilling mud suppliers maintain trained service personnel in major oil-drilling centers. They are available on call, at no charge, and it is advisable to have one of them visit any new project involving drilling with mud. The mud specialist can give helpful advice on the use of muds and mud chemicals and can analyze local water to determine if it requires treatment before use.

Processed bentonite-type drilling muds are particularly suitable because they provide high quality colloidal material. When mixed with water, bentonite mud is fluid as long as it is agitated, but gels immediately upon standing.

Functions: In drilling operations, mud performs several important operations.

1) *Removal of cuttings from the face of the bit and from the drillhole proper.* Viscosity of a mud fluid controls the rate at which drill cuttings will settle. If the mud pumps are stopped for any reason, gelling of the fluid locks the particles in place, and so prevents them from sinking and binding the bit. This function is particularly important in drilling iron-bearing material, where removal of heavy cuttings can become a problem.

2) *Wall-caking action to prevent caving.* A good mud fluid plasters the walls of a hole with a relatively impervious mud cake because the liquid portion of the fluid filters into fractures and porous wall surfaces, leaving solids as a dewatered layer.

3) *Improvement of core recovery.* By depositing a lubricating and protective film over the core as it enters the core barrel, mud fluids materially improve recovery, making it possible to core alternately hard and soft portions of a formation without grinding. Some geologists dislike the use of mud on the ground that it discolors the core. This is true if the mud is allowed to dry on the core, but there is no permanent dis-

Typical drilling fluid set-up. Water storage tank is at left. Mud pumps and tanks are scattered around and within pit excavation.

This tubular pump delivers up to 14 gpm at 600 psi and proved particularly useful in pumping cement and handling materials added to drilling mud. Mixing pump is at upper right.

coloration if the core is washed at once in clear water.

4) Elimination of casing. By controlling cave-in of ground, mud fluids can keep a hole open without casing for long distances, thus reducing the time and cost of completing a hole.

5) Reduction of rod friction and vibration. A slick, low-resistance mud film on the rods and on the walls of the hole facilitates pulling and eliminates the need for grease or other rod lubricants. A thick mud fluid also helps dampen vibration in the drill string.

A satisfactory mud mix for normal use in diamond drilling has a viscosity of 45 to 50 sec, as measured with a Marsh funnel. This viscosity rating represents the time taken, in seconds, for a quart of mud fluid to flow from a full funnel through a standard-size orifice at the bottom of the funnel. (Ed. Note: For details on field testing of muds, see W. D. Lacabanne's *Rotary Drilling Fluids in Exploration Drilling,* in the December 1954 issue of MINING ENGINEERING.) Clear water has a viscosity of approximately 26 sec. To provide mud of the desired viscosity, 2½ to 3 sacks of bentonite are mixed through a mixing hopper with about 400 gal of water. Complete hydration of a batch of mud takes about 24 hr, but the mud can be used immediately if necessary.

A good mud fluid requires conditioning additives. To each 400-gal batch, 1 qt of *Quebracho*, a tannin extract, is usually added to improve wall-building properties. Since Quebracho also thins the mud, it is desirable to add 1 qt of sodium carboxymethylcellulose (CMC), a thickener and lubricant. One quart of CMC in a 400-gal batch adds about 7 sec to the viscosity rating.

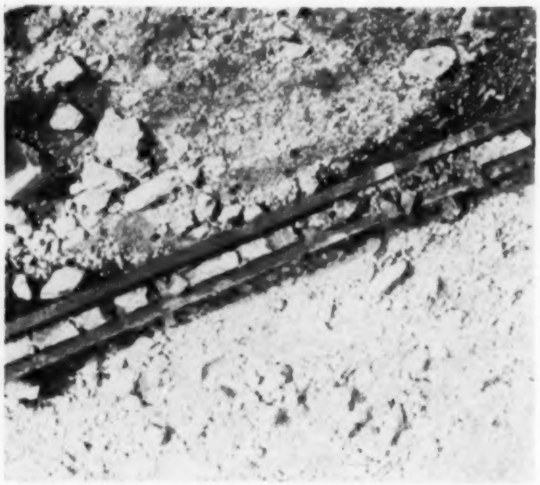
If the mud becomes thin, more bentonite or CMC can be added; if it becomes too thick, it can be thinned with water or a small amount of thinning chemical. Two thinners can be used: sodium tripolyphosphate (tripoly) added sparingly, 1 qt at a time, through the mixing hopper; or sodium hexameta-phosphate, added by simply hosing the mud through a few pounds of the flaky chemical placed in a bucket with some small holes punched in the bottom. The same mud can be used over and over again if it is *sweetened* daily with a quart of Quebracho and a quart of CMC. It is also recommended that a sack of bentonite, together with needed mixing water, be added to the drilling fluid for every 100 ft the hole progresses.

Mud return from the hole is, of course, recirculated. Before re-use, drill cuttings are allowed to settle, so that the sand content of the fluid is kept well under 1 pct. This may be measured with a simple sand content set. A regular settling tank is used at the return from the hole, followed by two 10-ft-long wooden troughs in series between the settling tank and the mud tank or pits. The V-shaped troughs are laid on an approximate 5° slope, with a 2-ft diam settling pit dug into the ground between the troughs. Baffles are set in the troughs at 3-ft spacing. Cuttings settle out in the settling tanks and troughs, and are removed at frequent intervals. In recent tests, sand content from the fluid return during coring usually ran about 0.25 pct solids. Use of a cyclone or other equipment for removing solids from the mud has been considered, but not tried. Needless to say, the mud going into the hole should be as clean as possible.

Standard clear-water diamond drill pumps are almost totally inadequate to handle mud. At the start of one project, two pumps, one with capacity to handle 30 gal of water at 600 psi, were continually clogging when mud viscosity was thicker than about 50 sec. This meant much down time on pumps, and, consequently, on drilling also. The problem was overcome by substituting a positive displacement piston-type mud pump with a capacity of 50 gpm at 1000 psi. The authors generally suggest this type of pump for mud circulation when drilling depths exceed 2000 ft. For normal drilling with complete

Marsh funnel is used in mud viscosity test. Man at upper left is standing on mixing tank while adding dry mud to mixing hopper. Pump is out of view, at right.

Trouble-shooting bits. BX-size carbide insert bit with EX-size pilot, on left, proved effective in drilling out stuck wireline rods. Tool steel bit in center was designed to ream collapsed joints on casing accidentally dropped in hole. Bit on right is typical tool steel rose bit.



As this core shows, some of the tested ground was highly fractured. A high percentage of recoveries were obtained with drilling mud. Core is usually removed from barrel hydraulically using drilling pump.

return, about 8 gpm is required for a BX-size hole, and 12 to 15 gpm for an NX-size hole.

Pumping pressures for drilling with mud normally will not run above 500 psi. Higher pressures are required for filling and for cementing zones of lost circulation.

A second pump for mixing mud is essential to good drilling practice. Satisfactory results have been achieved with a 600-psi tubular pump, and this also proves valuable for pumping cement slurry and filler materials. Since pumps lose efficiency if there is a suction load, such as may be caused by an intake located above the reservoir outlet, it is best to place the mud pump in the pit so gravity flow will be provided from mud tank to pump.

Troubles of lost circulation can often be overcome by circulating extra thick mud of 60 to 70 sec viscosity. Clearances of BX-size coring equipment do not permit circulating mud thicker than about 50 sec, although this can be slightly improved by making modifications to increase internal clearances in bits, shells, and barrels. NX-size coring equipment allows passage of thicker muds of about 65-sec viscosity. In ground known to be fractured, it may be cheaper to drill an NX hole instead of a BX hole, since the circulation of thicker muds is likely to reduce the time lost in filling and cementing.

When thicker mud does not bring back full return, there may be open fractures, which can be effectively sealed with filler materials such as bran, walnut husks, cotton-seed hulls, and shredded cellophane, to name only a few. Some 2 to 4 pct by volume of these materials in the mud will often bring back complete return.

Mud fluids are not as effective when used solely as a cure for trouble as when used to condition a hole from the start. After employing mud to get through bad ground, the drill crew should never switch to plain water without first setting casing or cementing. Otherwise, the mud walls may collapse and the hole cave in. Any hole left idle, as for a weekend shutdown, should be filled with mud to prevent wall deterioration. If loss of circulation fluid is experienced, it may not be enough simply to fill the hole with mud at the time of shutdown because groundwater circulation through the hole will gradually dilute the mud and reduce its effectiveness. In such cases the best solution is to cement the zone of lost circulation or to arrange for washing the hole with thick mud at regular intervals.

Quick-Setting Cements

If there is a complete loss of circulation and fluid-losing zones cannot be sealed off with filler materials, the hole may start to cave and will require cementing. It is usually possible to drill without fluid return for a while—even though mud alone will probably cost $2 to $3 per ft—but eventually the mud is washed or wiped away, or dries out above the porous zone, and the hole starts to cave in. When caving persists, the hole must be cemented or, sometimes, cased.

It is not unusual to encounter running water within certain zones in a hole and cementing such ground is often difficult. Regular Portland cement, which takes 8 hr or more to set, frequently becomes diluted or washes away before setting. In practice, Portland cement was put in a drill hole on several occasions and after a 16-hr wait for it to set, no cement was found in the hole. Adding 2 pct $CaCl_2$ to the slurry sometimes helped, but the characteristics of Portland cement are not predictable under such conditions, and its setting time is variable.

A well-known brand of quick-setting cement was tried in several deep holes but this also gave quite variable results. The age of this cement appears to be an important determinant, and it is suspected that water chemistry, mud contamination, and simple dilution also affect its setting characteristics.

Application of Gypsum Cement: After several unsuccessful attempts to cement drill holes with different Portland cement mixes and with the quick-setting cement mentioned above, a quick-setting gypsum cement was tried. One such cement successfully used is available with either a 30 or 60-min set. In preparing the slurry, 5 gal of water are mixed with each sack. This cement sets solid about 10 min after it starts to stiffen.

The 60-min gypsum cement is often used in deep drilling. Surface samples taken from each batch begin to stiffen at times ranging from 55 min to 1 hr 40 min after starting to mix. Variations in setting time are nearly always on the safe, or longer-setting, side.

Gypsum cement is applicable to core drilling for a number of reasons: it is pumpable during 80 pct of the setting time; it sets while flowing and at temperatures up to 140°F; its lineal expansion in setting is 0.3 pct; it attains near-maximum compressive strength of 2500 psi an hour after setting; it will set within 2 hr or it will never set, so rods can be lowered safely only 2½ hr after mixing; and its relative softness makes the cement easy to drill out.

In practice, the following procedure was adopted for cementing with 60-min gypsum cement:

1) Calculate volume of slurry required in drillhole. For normal cementing, prepare about twice this volume, and three times as much if circulation return is poor. Thirty gallons of water mixed with six sacks of cement gives about 55 gal of slurry. In theory, this quantity is enough to fill about 240 ft of BX-size drill hole.

2) With wash rods in the hole to the level to be cemented, calculate volume inside the drill

string. A 1500-ft string of BX wire-line rods holds 200 gal of fluid.

3) If drilling with mud, pump some 20 gal of clear water into rods before placing slurry. This cleanses mud from inside rods and dilutes some of the mud cake on hole wall.

4) Pump the calculated amount of slurry into the drill rods. Assuming that about 120 ft of BX hole is to be cemented at a depth of 1500 ft break open six sacks of gypsum cement and place them alongside a mixing tank containing 30 gal of water. With pump intake in the mixing tank and with mud pump on *high,* circulate the mixing water in a closed surface circuit, hosing the water back into the tank. Start mixing by pouring cement into the tank and spraying it with the hose. Mix quickly, roughly one sack per min. When all six sacks are mixed, circulate the slurry for 2 or 3 min more, breaking up any lumps by hand. After taking a small surface sample of mix, pump slurry immediately into the drill rods.

5) If drilling with mud, slurry should next be followed with 20 gal of water to cleanse the rods, and then with the calculated quantity of mud to complete rod filling. When the cement reaches the bottom, there will be a sudden rise in pumping pressure.

At the time of pumping the 20-gal *pill* of water into the rods behind the slurry, the mixing hose should be cleansed by pumping additional water through it. Pumping the follow-up mud into the hole must be done without delay.

6) When cement reaches the bottom of the hole, pull up the first stand of rods and stop pumping. Then open vent hole in swivel plug so that cement inside rods can fall out by its own weight and the weight of follow-up mud above it. (Gypsum cement slurry weighs about 110 lb per cu ft, compared with 67 lb for mud and 62½ lb for water.)

Pull rods slowly for the first 100 or 200 ft, and then rapidly. They should be well clear of the cement not later than 40 min after starting to mix. (This shortened time interval, of course, limits depth to which a 60-min cement may be safely employed.) After pulling each 200 or 300 ft of drill rods, it is a good idea to fill the rods with mud to insure that hydrostatic head in the hole is higher inside rods than outside.

7) Two and a half hours after the start of mixing, a finger bit can be put down to drill out the cement. For the last 200 or 300 ft, fluid should be pumped into the hole because diluted cement that has not set will usually be found lying above the hardened cement. When drilling with mud, use a thin mud to drill out cement—cement cuttings thicken the mud and make pumping more difficult. With a finger bit, about 200 ft of gypsum cement can be drilled out per 8-hr shift.

Gypsum cement should never be mixed with Portland cement. This combination may produce a *flash* set, resulting in solidification in as little as 12 min.

Back-Off Shooting

It sometimes happens in core drilling that drill rods become stuck in a hole, and the trouble can generally be traced to cave-ins, cuttings, or other obstruction. Stuck rods may sometimes be jarred loose in a deep hole, but stretch in the rods makes jarring rather ineffective and attendant vibration can aggravate a caving condition. Stuck rods are usually backed off as far down the hole as possible. Then additional rods are removed either by washing or reaming over. Rods abandoned in the hole may be drilled out, or by-passed using wedging techniques.

In conventional core drilling, stuck rods are usually backed off by hand. Each joint of the free rods is rosined and tightened as much as possible, using pipe wrenches, as the string is lowered into the hole. Using a tap to engage the stuck rods, the string is backed off to break a joint below the rosin-tightened rods. The process can be simplified by using a string of left-hand-threaded rods, if such a string is available. In a deep hole, backing off by hand may well consume a week or two. With wire-line or N-size rods, the inside diameter of the rod coupling is large enough to permit adaptation of an oil-drilling technique known as back-off shooting. This technique may also be applied to casing.

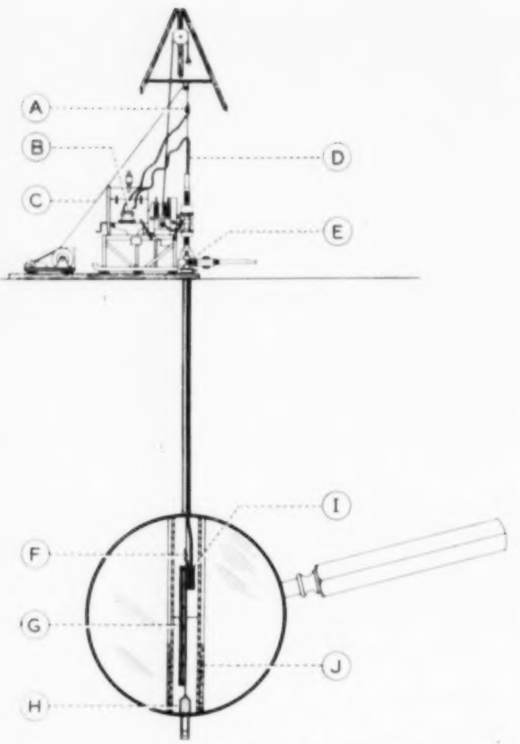
Briefly, a short length of Primacord detonating fuse is centered across the joint to be broken. Weight of the rods at that point is neutralized, a reverse torque is applied to the drill string, and the shot is detonated. The shock of detonation forces a momentary expansion of the joint and the applied back-off torque causes the joint to unscrew slightly, without damage to rods or threads. All rods above the free joint can then be removed from the hole.

Method in Practice: A short length of detonating fuse is taped to a 3/16-in. diam wire rope, which is attached to a 10-ft length of 3/4 in.-OD pipe filled with lead. This weight is tapered at each end to permit ease of travel inside drill rods. The wire-line cable and reel are ideal for lowering the fuse and weight. One lead of an electric blasting cap taped to the detonating fuse is grounded to the wire-line cable; the other is attached to an insulated single-conductor wire running alongside the cable to the surface. To place the shot properly, the length of cable in the hole must be accurately measured and it is useful to have a measuring assembly attached to the cable reel.

When the shot is positioned across a joint in the hole, the rods are first tightened to take up any slack in joints above the point of binding. Next, almost a full turn of reverse, or back-off, torque is applied while the hydraulic head of the drill takes the weight of the drill string. The battery for the drill engine is grounded to the wire-line cable, and the shot is then detonated by touching the single-conductor lead wire from the blasting cap to the live terminal of the battery.

Another, probably more foolproof, method for wiring the shot calls for a two-conductor insulated electrical cable instead of the single-conductor wire and 3/16-in. diam wire rope mentioned above. Surface ends of the two conductors are first shorted by twisting together. Then the leads from the blasting cap are taped to the ends of the conductors, which go in the hole. The cable is taped to the wireline as it is dropped in the hole. For firing, the surface wires are untwisted and the electrical circuit completed by touching the wires to the battery terminals, or by hook-up to a regular blasting machine.

If the particular joint is freed by the shot, it will be felt at once by the man holding the back-off wrench at the surface. The joint can then be loosened by hand. If the joint remains fast only a slight tap will be felt at the surface. In this case, rods are presumed tight in the hole at that point,



General arrangement and electrical circuitry used in back-off shooting: A) Battery grounded to wireline when ready to shoot. B) Shot detonated when ready by touching wire to drill battery. C) 3/16-in. wireline cable. D) Insulated cable taped to wireline at 25-ft intervals. E) Drill string tensioned by drill head and back-off torque applied by hand before detonating shot. F) Cap grounded to wireline cable. G) Short length of detonating fuse taped to wireline across lowest free joint to be backed off. H) 3/4-in. OD pipe, 10 in. long, and weighted. I) Electric blasting cap taped alongside detonating fuse. J) Core barrel and lower joint in caved material.

and another joint is tried higher in the hole. Care must be taken not to place too strong a shot, or too many shots, at any one joint, particularly with casing. Generally, BX wire-line or N rods can withstand two or three shots of single-strength Primacord at the same spot without damage, but further shooting may cause belling and occasional cracking. If some is available, it will be safer to use a less powerful fuse than regular Primacord.

Several firms in the oil-drilling industry specialize in back-off shooting. They also provide a *free-point indicator* service for the purpose of finding the lowest free joint in a string of stuck drill tools. This is done by using an electronic strain gage to measure tension and torque at various depths in the string. Minimum inside rod diameter in which this equipment now used is about 1¾ in.

For quick removal of stuck rods below the lowest free joint, it has been found advisable to wash or ream over such rods with appropriate-size casing, using a specially-made casing shoe. This method permits drilling through cave-ins or other obstructing material. As an example, this method was used to retrieve a string of 2 3/8 in.-OD N rods in a 3-in. NX drill hole, by drilling over them with flush-joint BX casing of standard 2 7/8 in. OD and 2 15/32 in. ID, thus giving 3/32-in. clearance around the rods. A casing shoe, which is standard BX on outside diameter but 2 27/64 in. ID, is attached to the casing string, giving 3/64-in. clearance around the N rods. In difficult ground, such a casing string usually starts to bind after progressing 150 to 200 ft. It is safest to pull the casing after 90 or 120 ft, and then apply a back-off shot to free and remove the rods to that point. This procedure is repeated until all the rods are freed. Of course, where only a short length of drill rod is stuck a comparative short distance below hole casing, and if that casing can be safely pulled, the hole may be reamed down to recover the entire drill string. Obviously, circumstances should determine method.

Wire-line rods are somewhat difficult to remove when stuck because they do not have sufficient outside clearance in the drill hole to allow use of wash-rods. On the other hand, this small clearance permits only small pieces of caved material to get around the outside of the rods, and this favors their removal. In cases where wire-line rods and the outer tubes of wire-line core barrels are stuck tightly, they may be removed by first cutting them into 5-ft sections with casing cutter and removing each section piecemeal with a tap. An AX-size casing cutter is used for BX-size rods.

As a last resort, stuck steel may have to be drilled out. In drilling out BX wire-line rods, it has been demonstrated that diamond bits do the job, but at relatively high cost. Even with heavy-set pilot bits, bit life in one case averaged only about 12 in., and penetration rates ranged from 4 to 6 in. per hr. In an effort to improve this performance, custom-made tungsten carbide insert-type bits were tried.

The BX-size carbide bit which proved most satisfactory was faced with eight cutting inserts and had a 1½-in. diam EX pilot bit screwed into its center. This type of bit cut at an average rate of 18 in. per hr and drilled about 3 ft before having to be pulled. It worked best when turned rapidly, with light pressure. The bit had to be withdrawn for resharpening when the cutters started to dull—evidenced by a slackening rate of penetration.

Besides lower initial cost, the carbide-insert cutting bits gave three times the penetration rate of diamond bits and three times the footage per use.

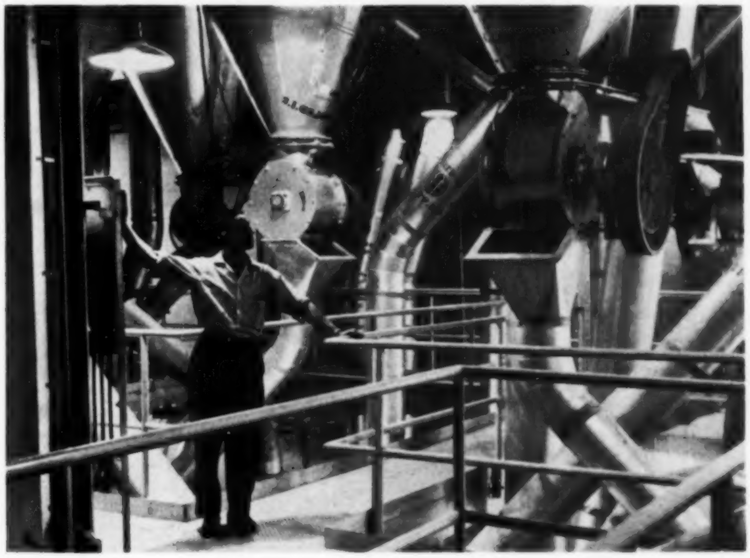
Summary

Techniques described involve use of commercially-available equipment and include the use of mud and mud chemicals for control of caving and improvement of core recovery, use of quick-setting gypsum cements for sealing troublesome sections of hole, and use of detonating fuses to back off stuck drilling tools.

Problems created by deep drilling are as much economic as they are technical, and better equipment and drilling techniques are basic to the solution. Those involved in exploration work, both directly and indirectly, must accept the challenge posed and a coordination of research, development, and application appears to be the best hope. Drilling symposiums, technical papers, and trade journals are excellent media for discussing problems, exchanging ideas, and publicizing progress. We can rest in our efforts to seek improvement only when we have the satisfaction of knowing that the bit placed in the hole will cut rapidly throughout its extended life, without rest.

ASBESTOS PRODUCTION UNDERWAY AT BLACK LAKE

Lake Asbestos of Quebec's recently-dedicated mining and milling operation has begun output from a lake-bottom deposit that was uncovered only after 55 billion gal of water were pumped off and 27 million cu yd of mud and silt were removed. Open pit work alone is expected to yield 100,000 tons annually for 20 years.



At Black Lake, Quebec, Lake Asbestos of Quebec Ltd., a wholly-owned subsidiary of American Smelting and Refining Co., has opened a $36-million mining and milling operation which will produce about 100,000 tons of asbestos fiber a year and add 7 pct to the Free World's supply.

The orebody once lay beneath Black Lake, and readying the ore deposit for open pit mining meant removing about 37 million cu yd of overburden—30 million cu yd by dredging and pumping, and 7 million by power shovels and trucks. The enormous amount of material to be dredged, control of drainage during dredging, the need to cope with drainage problems in the area and to provide for flood control to replace the regulating effect of the lake, posed unusual engineering challenges and required tremendous capital investment.

MINING OPERATIONS

Under the agreement by which Asarco undertook the venture in conjunction with United Asbestos Corp. Ltd.—the company holding mining rights to the Black Lake deposit—Asarco is to supply the necessary capital for the development of the property and operate it for the life of the orebodies on a profit-sharing basis.

Although dredging will continue until early 1959, the lake was low enough in mid-1958 to permit the start of mining and certain operations in the mill. Open pit mining should be possible for about 20 years; after that underground methods will probably be necessary. Ore reserves are presently estimated at 42 million tons.

Since preventing contamination is very important in both mining and milling, the orebody must be carefully cleaned before it is blasted, crushed, and milled.

Ore being mined at present is from two of the three known orebodies under Black Lake. The standard method of mining is by quarrying in 40-ft benches.

One orebody starts at about elevation 630 ft, the other at about 670 ft. The original lake level was at 750 ft and will be at 530 ft when completely drained. Open pit operations will go down about 500 ft and then may be extended another 500 ft by underground methods.

Primary blast holes are drilled 6 5/8 in. diam and are spaced at 10 to 15 ft with a burden of 20 to 30 ft. Secondary blasting and block-holing is done by tractor-mounted wagon drills and by travel drills. Ore is loaded into 25-ton capacity rear-dump trucks by 4-cu yd shovels and dumped into a 100-ton capacity steel hopper chute.

Maximum cleanliness of mill feed is insured by flushing away the small amount of remaining overburden.

A travel drill is used to prepare for further blasting any oversized chunks of ore resulting from the primary shot.

MILLING OPERATIONS

The $9.2 million mill building has 11 floors and is 130 ft high. Production equipment and quality control facilities are very modern, and ore quality permits production of all grades of asbestos from the longest to the shortest fibers. Capacity of the mill is 5000 tpd of ore.

Separating the asbestos fiber from its host serpentine is accomplished by repeated crushing, fiberizing, removing free fiber by suction, and screening the freed fibers to remove rock and dust.

Ore from the mine is dumped into a chute in the primary crusher building. From the 100-ton-capacity chute, ore is fed by a Stephens-Adamson 18x5-ft heavy duty pan feeder to a 48x60-in. Traylor jaw crusher set for about 6½ in. product.

Ore is then conveyed by a 42-in. rubber-covered conveyor belt to two 5x12-ft Tyler 4-in. mesh vibrating screens. Oversize is conveyed to a 7-ft Symons cone crusher, undersize to an outdoor wet rock stockpile.

Wet Rock Storage: The outdoor pile has a normal capacity of 120,000 tons, or about a month's run for the mill.

Using the wet rock pile permits:

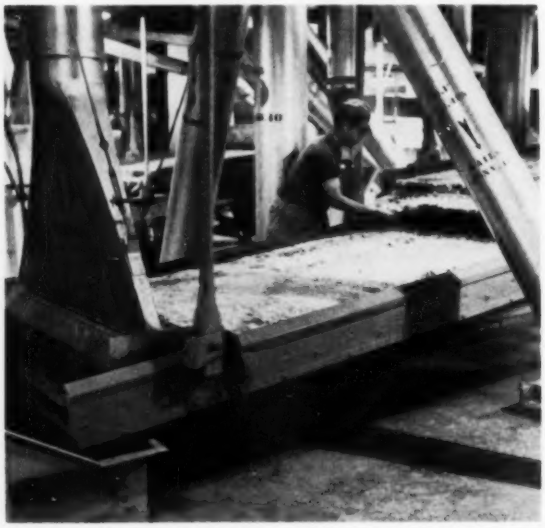
1) Blending ore from the two orebodies.

2) A steady supply of ore for the mill in case major repairs are scheduled for primary crushing or mining equipment.

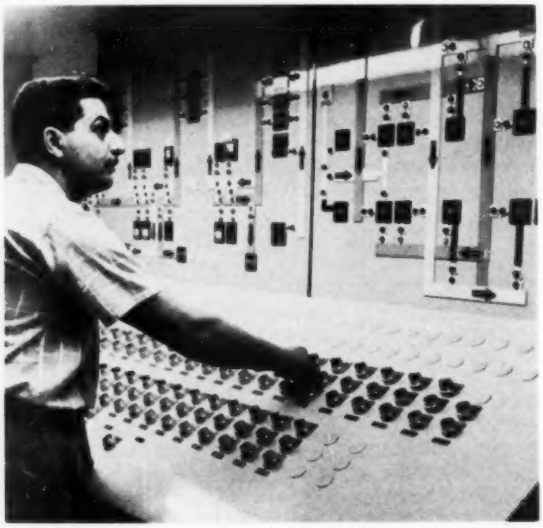
3) Feeding the driers at constant tonnage, 24 hr a day.

Dry rock is necessary for efficient mill operation. A conveyor belt, fed by automatically controlled feeders located in a recovery tunnel under wet rock storage, supplies ore to the drying department. At the head of the section, ore is separated into +2 and −2-in. mesh. Coarse material is bypassed around the driers except when ore is extremely wet or contains an abnormal amount of snow or ice. The rock is dried in rotary, oil-burning driers, in which temperature conditions are varied according to moisture content of the rock.

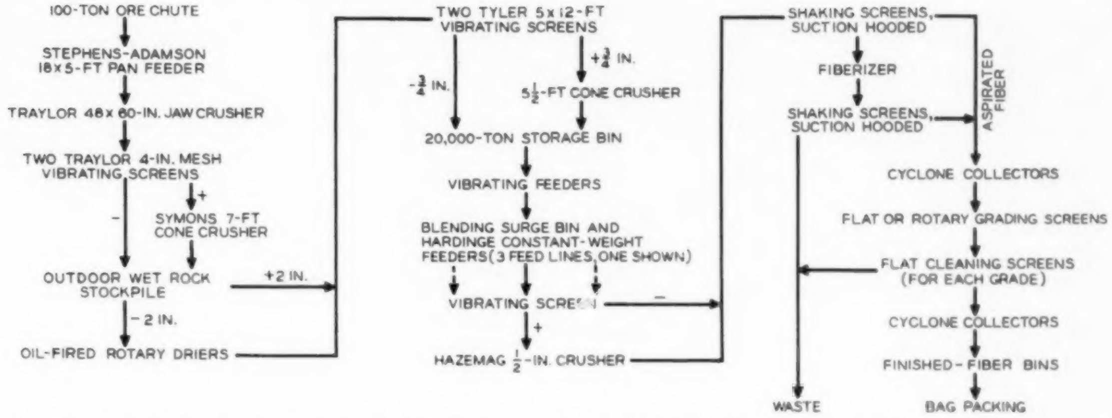
After drying, the ore goes to two 5x12-ft Tyler



Asbestos fibers and rock are separated on screens that shake fibers to surface where suction hoods claim them.



From this control board an operator regulates the flow of asbestos from bins to packing area for shipment.



Condensed flowsheet showing nature of main operations at Lake Asbestos mill. Dust-producing points are connected via cyclone collectors to a vacuum chamber bag filter room located at the top of the mill building. Clean air from this room is exhausted or recycled to mill interior for heating. Barren rock particles and filtered dust go to waste dump.

¾-in. mesh vibrating screens. Plus material goes to a 5½-ft cone crusher (a second 5½-ft cone crusher is to be added soon); minus material goes to a covered 20,000-ton dried-ore storage bin. From the tunnel beneath this bin, dried ore is fed by automatically controlled vibrating feeders to the mill.

Air Separation of Fibers: Dry crushed ore is fed to heavy shaking screens equipped with powerful air suction hoods. Sand is screened out, and as the ore moves along, the fiber rises through the rock fragments and is removed by suction as it passes under the hood. Openings in the screens are kept from blinding by rubber balls that bounce under the perforated plate.

The screens are aspirated by exhausting air from the top of cyclone collectors through a bag filter chamber at the top of the mill. Air is exhausted from this chamber by six 350-hp fans. Clean air is returned to the mill, or outdoors, through adjustable louvers.

At the head of the mill the ore is fed to three identical rock lines by a blending surge bin equipped with Hardinge constant-weight feeders. Rock from the first vibrating screen goes to a further crushing stage which reduces it to about ½-in. mesh. Then it is again passed over a shaking screen equipped with a suction hood. Finally, rock from this screening is fed, together with smaller material from the initial rock screening, to a fiberizer.

The fiberizer employs high-speed hammers and has a more severe action than the crusher, which breaks by compression. Hence it is not used until the longer, more valuable fibers have been removed. Ore from the fiberizer, like material from the crusher, is fed to hooded shaking screens for separation of fibers.

Asbestos is cleaned and graded by feeding the fibers to cyclone collectors. Heavier fractions, comprising rock particles and unopened fibers, fall vertically; air suction draws the lighter asbestos fibers off sideways to be graded according to length by passing through flat or rotary screens.

The grading screens have three sections, each covered with a wire cloth of different mesh. Fibers fed into one end of the screen are agitated by revolving paddles which force short lengths through the screen of the first section and eject longest grades at the end. Each grade falls on a flat cleaning screen where sand, dust, and unmilled splinters are removed.

Waste from all screening operations, normally about 90 pct of the original ore, is conveyed to tailings dumps. The mill is unique in that about 35 pct of the original feed can be rejected to tailings after the third screening operation. This relieves the 3rd and 4th-stage milling machines of a considerable load and minimizes sand, dust, and rock powder.

The fiber, after blending in the graders, is screened and lifted into cyclone collectors which discharge into finished fiber bins. Fourteen such bins collect the standard grades: spinning, shingle, paper, stucco and plaster, and shorts.

From these bins, the bottoms of which are equipped with six spiral screws, material is automatically fed for bagging to five pressure packers (eventually eight), four St. Regis, and four vertical-screw packers. Subsequently it is transported to warehouse, railroad cars, or trucks.

MARKETING

In entering what is for it a new field, Asarco will continue its basic company policy of supplying raw materials to industrial consumers and will not itself make asbestos end-products.

Black Lake offers Asarco a product that is less cyclical that non-ferrous metals, and which should lend greater stability to its sales pattern. The consumption curve of asbestos, tied as it is to products related to the expanding needs of an ever-increasing world population, has been going steadily upward. Another advantage is that the price of asbestos is relatively steady.

In terms of return to the company, it is indicated that the average price of fiber produced will be about $130 per ton, yielding a gross annual revenue of $13 million based on 100,000-ton production.

In 1953, according to the U. S. Bureau of Mines, world asbestos production, exclusive of Russia, totaled 1,375,000 tons, of which 826,000 tons originated in Canada. In 1955, Canadian production was estimated to have approached a million tons. Better than 60 pct of Canadian production goes to the United States; the balance is exported to such free-world countries as Mexico, South American nations, Australia, Japan, and Western Europe.

Problem: *Drill out an orebody and sink a shaft only to find no signs of mineralization.*

Cause: *Bad drifting of exploration drill steels.*

Solution: *Directional drift surveys on test holes.*

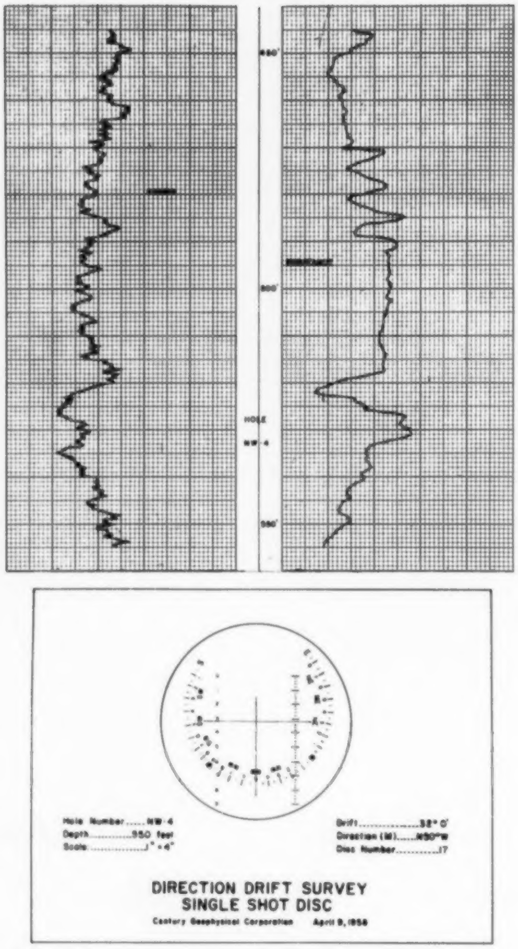


Fig. 1—Portion of Gamma-R log for hole NW-4 and directional drift survey disc.

Field experience in uranium has shown it is most economical to ram through a drilling program to obtain maximum footage per drill hour. Drift surveys can then determine the course of the holes. Using this method is generally cheaper than paying the additional cost involved in using the drilling technique and equipment necessary to maintain straight holes.

Factors Affecting Direction of Bit Travel: In all rotary-drilled holes there is an interplay of forces or conditions affecting the direction of bit travel. Rarely is a straight vertical hole obtained.

One of the major factors is weight on a drill string. In looking at a joint of drill stem it is hard to imagine its being quite flexible, but flexing of the steel increases when many joints are made up together, and even a slight weight added to the

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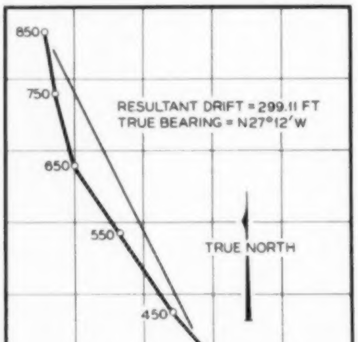


Fig. 2—Derived from drift survey of hole NW-4. Plan view above.

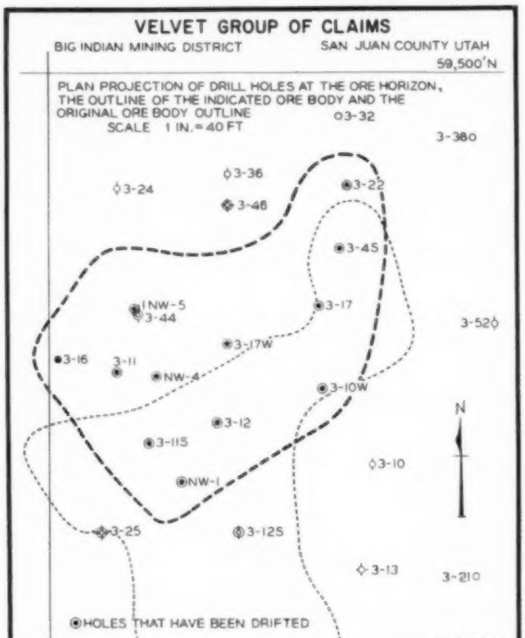


Fig. 3—Orebody outline indicated by assumed vertical projections of exploration holes. See Figures 4 and 5.

THE CASE OF THE ELUSIVE OREBODY

by A. J. NICOL

upper portion causes a buckling or spiraling effect in the hole. The result is that the bit deviates from the vertical.

A hole may also drift because of formation dip. The exact mechanical analysis of the effects of formation dip upon the direction of hole drift is controversial, but, generally, there is a tendency for a bit to creep up dip.

A third major factor in crooked holing stems from the tendency of the bit to walk at right angles to the point at which it makes maximum contact with the formation.

All three effects can be minimized by the use of drill collars, sharp bits, fast rotation, high pump pressure, and by decreasing the weight on the bit, etc. However, these remedies slow drilling and reduce footage production, thereby increasing overall costs.

Of the many instruments available for measuring borehole drift and deviation, the simplest is the stylus instrument which merely punches a hole in a disc, marking the drift angle in degrees. More effective instruments are the single and multi-photographic types, which give not only angle of inclination but also direction of hole deviation.

The performance of any of the three instruments must be synchronized with a surface watch and in-hole tool watch. A line or cable arrangement is also necessary to lower the tool to the depth where measurements are to be made. An accompanying illustration shows a wireline truck used for such surveys.

Typical Drift Survey Data: See Fig. 1. Borehole NW-4 is calculated to have a drift of 32°, with a bearing of N50°W at a depth of 550 ft. This is an abnormally large amount of drift but is indicative of the extreme inclinations possible. A portion of the Century Gamma-R log for hole NW-4 is shown above the directional drift survey disc.

Fig. 2 is a tabulation sheet computed from the drift survey of hole NW-4. Resultant direction and drift of the hole are calculated by using latitudes and

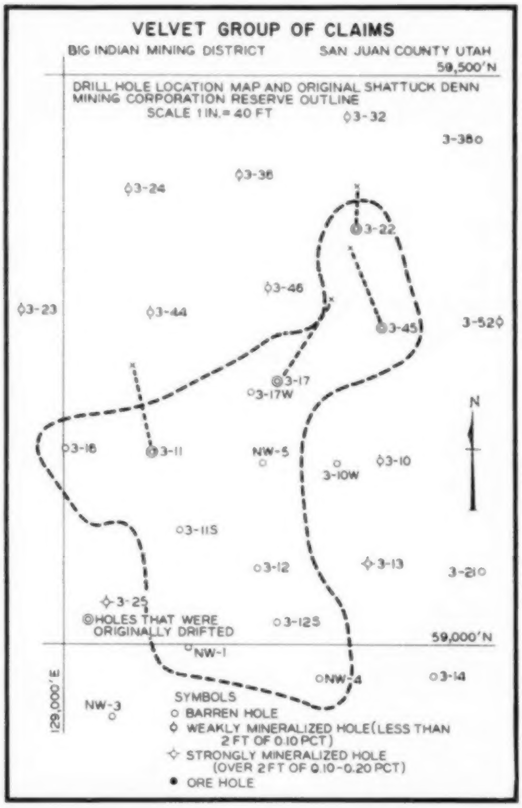


Fig. 4—Plan projection of drill holes showing resultant drift.

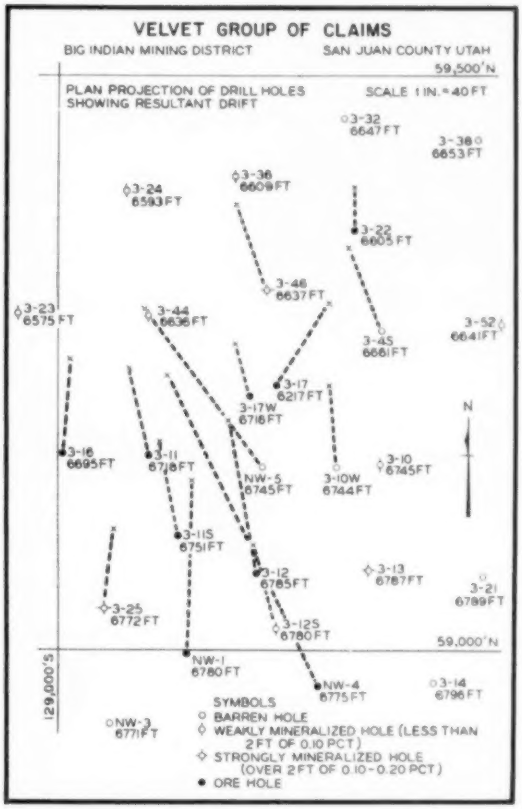


Fig. 5—Plan projection of drill holes at ore horizon and indicated and original orebodies.

Possible wide deviation from vertical is demonstrated by the course of this borehole.

This wireline truck is typical of those used in lowering tools for the measurement of borehole drift.

departures; polar coordinates are used as an additional check of these data. A plan view of the survey is shown in Fig. 2.

The location of the borehole at the surface is shown in the lower center edge of the plat; the true position of the bottom of the hole is shown in the upper left hand corner. Total resultant drift for hole NW-4 is shown to be 298 ft, with a bearing of N27°W. Total loss of vertical depth due to inclination of the borehole is estimated to be 66.65 ft in a total depth of 850 ft.

Clearly deviations of this magnitude in drift and bearings of boreholes can lead to critical errors in mineral exploration programs unless properly corrected. Underground location of the orebody would be erroneous, and estimated ore reserves subject to wide variation from actual reserves because a representative thickness of mineralized zones is not being tested by the inclined boreholes.

Fig. 3 shows an outline of an orebody in San Juan County, Utah, as indicated by assumed vertical projections of original exploration holes. A drift survey was run on four of these original holes. Deviations from 36 to 210 ft in various directions were measured.

From even this sparse information it became certain that the location and extent of the orebody were in doubt. In addition, estimated ore reserves were sure to be in error. The true thickness of the ore strata is equal to the original indicated thicknesses times the cosine of the angle of deviation. Subsequent exploration holes were drilled and additional drift surveys were obtained. Fig. 4 shows true bottom-hole deviations of the magnitude of 36 to 298 ft in various directions, generally up dip.

A true plan projection of the ore horizon for each hole was made by correcting each borehole for inclination and deviation. The outline of the indicated orebody (broken lines) is shown in Fig. 5. The shift of the indicated orebody is shown by the dotted line delineating the limits of the original orebody.

The value of such drift surveys of boreholes to the mining engineer is obvious. Vital information is provided to solve many basic mining problems.

ACKNOWLEDGMENTS

Thanks are expressed to Shattuck Denn Mining Co., Mid-Continent Uranium Corp., and Century Geophysical Corp., for their assistance and cooperation in supplying certain technical data.

Drift Survey Tabulation Sheet

	Measured Length		Vertical Depth		Direction of Deviation								Unit Displacement North		Unit Displacement East		Unit Displacement West		Total Displacement		
Time or Disc.	Course	Total	Course	Total	Observed			Corrected	Corrected			Angle of Incln.	100 Ft	Course	100 Ft	Course	100 Ft	Course	North	East	West
1	50	50	49.90	49.90	N	5°	W	−15°	N	10°	E	3°45′	6.44	3.22	1.14	0.67			3.22	0.57	
40	50	100	49.60	99.50	N	6°	W	−15°	N	9°	E	7°15′	12.46	6.23	1.97	0.99			9.45	1.56	
4	50	150	49.13	148.63	N	18°	W	−15°	N	3°	W	10°45′	18.63	9.32			0.97	0.49	18.77	1.07	
2	50	200	48.46	197.09	N	29°	W	−15°	N	14°	W	14°15′	23.89	11.95			5.96	2.98	30.72		1.91
14	50	250	47.62	244.71	N	40°	W	−15°	N	25°	W	17°45′	27.63	13.82			12.89	6.45	44.54		8.36
3	25	275	23.49	268.20	N	46°	W	−15°	N	31°	W	20°0′	29.31	7.33			17.61	4.40	51.87		12.76
5	25	300	23.18	291.38	N	49°	W	−15°	N	34°	W	22°0′	31.06	7.77			20.95	5.24	59.64		18.00
15	50	350	44.94	336.32	N	57°	W	−15°	N	42°	W	26°0′	32.58	16.29			29.33	14.67	75.93		32.67
16	100	450	88.50	424.82	N	56°	W	−15°	N	41°	W	27°45′		35.14				30.55	111.07		63.22
17	100	550	84.81	509.63	N	50°	W	−15°	N	35°	W	32°0′		43.41				30.39	154.48		93.61
18	100	650	88.90	598.53	N	50°	W	−15°	N	35°	W	27°15′		37.51				26.26	191.99		119.87
19	100	750	91.00	689.53	N	31°	W	−15°	N	16°	W	24°30′		39.86				11.43	231.85		131.30
20	100	850	93.82	783.35	N	24°	W	−15°	N	9°	W	20°15′		34.18				5.42	266.03		136.72

Loss of vertical depth = 66.65 ft.

POLYACRYLAMIDES FOR THE MINING INDUSTRY

A new type of flocculant is raising efficiency, lowering costs. Greater operating capacity made possible is changing plant set-ups, equipment design.

by MERRILL F. McCARTY and ROBERT S. OLSON

New organic flocculants of high-molecular weight are replacing lime, glue, and starch in liquid-solid separation. Of these synthetic materials, polyacrylamides are outstanding.

Polyacrylamides form a class of compounds varying widely in composition and activity. Separan 2610[R], one of the first of these flocculants[1] released to the mining industry in 1954, is described[2] as a high-molecular weight polymer of acrylamide with or without a copolymer material and with some replacement of amide by carboxylic groups.

MECHANISM OF FLOCCULATION

In practice, flocculation makes solids settle faster and filter better. But two opposing factors control it. The random motion that causes particles to collide favors Van der Waals' forces, which hold the particles together. The effect of zeta potential opposes this contact, and particles are mutually repelled. Flocculation can be achieved by reducing the magnitude of the zeta potential; this is the mechanism of flocculation by lime addition.

The way in which polyacrylamides accomplish flocculation is not fully understood, but the action is undoubtedly complex and probably varies considerably depending on the system. To begin with, the active groups of these compounds have an extremely high affinity for solid surfaces, probably by hydrogen bonding.[3] Initially some active groups of the molecule attach themselves to the solids with a large portion of the molecule extending into the solution. Two particles can become tied together by long flocculant molecules in the following ways—by bonding between the active groups of two flocculant molecules on different particles, or by an extended molecule from one particle attaching itself directly to the surface of the other particles.[4,5] These flocculant bridges prevent the particles from moving apart through random motion, but when such motion moves them together other active groups on the flocculant bridge bond to the solids, holding them in the closer position. This process is repeated until the particles are close together.

F. F. McCARTY, Member AIME, is a Metallurgist with Dow Chemical Co., Midland, Mich. R. S. Olson, Member AIME, is Project Leader, Dow Chemical Co., Pittsburgh, Calif. TP 4775B. Manuscript, May 6, 1958. New Orleans Meeting, February 1957. AIME Trans., Vol. 214, 1959.

Although bridging is probably a major flocculation mechanism, it is not the only phenomenon involved. Relatively neutral acrylamide flocculants reduce the magnitude of the zeta potential by increasing the viscosity of solution in the immediate vicinity of the solid surface which contains the mobile counter ions of the double layer. In other words, it moves the shear surface which bounds the zeta potential out into the solution containing counter ions which tend to neutralize the zeta potential. This effect is probably more pronounced during the initial adsorption period, before the flocculant molecules are pulled close to the solid.

In some cases the slight charge of the polyacrylamide molecule tends to neutralize a zeta potential. However, this is not a primary flocculation mechanism, as evidenced by the fact that the polyacrylamides will flocculate solids with either positive or negative zeta potential.

Adsorption of polyacrylamide flocculants by a solid is substantially an irreversible reaction. Since the flocculant molecule is attached to the particle surface by many active groups of high bonding strength, desorption would require the simultaneous breaking of many bonds—an unlikely occurrence.

UNIQUE PROPERTIES

The irreversible adsorption of certain polyacrylamides, the flocculant's high affinity for solid surfaces and its rapid adsorption make it effective, but these unique properties require special techniques to achieve maximum flocculation.

If flocculants of this type are added to a pulp as a relatively concentrated solution, the solids in the

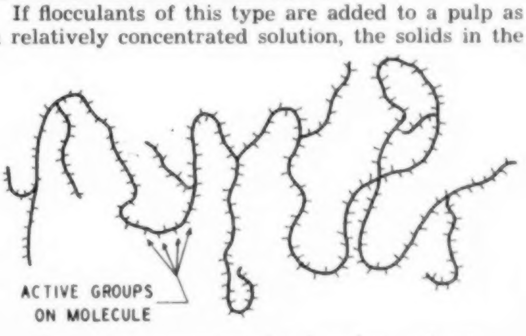
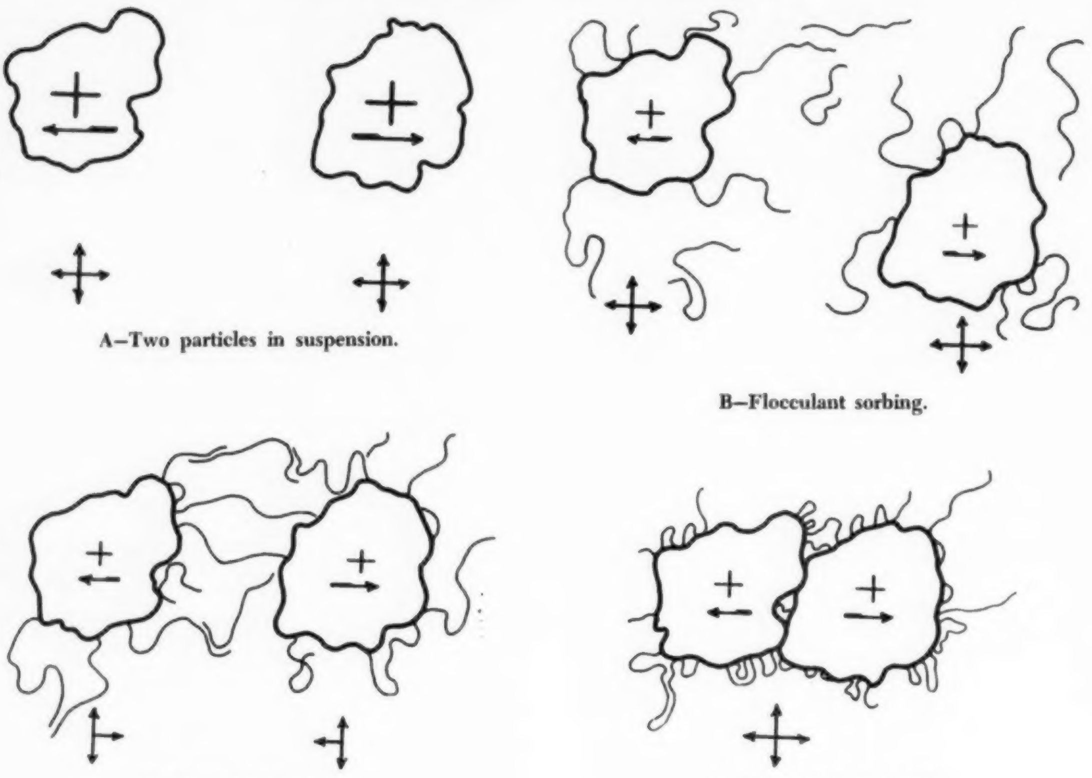


Fig. 1—Representation of a flocculant molecule.

Fig. 2—Mechanics of flocculation by Separan 2610.



A—Two particles in suspension.

B—Flocculant sorbing.

C—Flocculant bridging.

D—Particles flocculated.

vicinity of the addition point adsorb all of the flocculant rapidly and completely. The bulk of the pulp thus remains unflocculated—an undesirable condition. To insure optimum flocculation the reagent must be distributed uniformly throughout the pulp.

Better distribution can be obtained by slowly adding the reagent solution to the system while gently agitating the pulp, so that all the pulp is exposed to the flocculant addition point. This method is not very practical in flowing systems, but it can be approximated by multiple point addition of solution to the system. If dilute solutions are used distribution is further improved, since the large solution volume mixes more uniformly with the pulp in a short period of time. These effects are illustrated in Fig 3, which shows the free settling rate (initial rate) of an acid leach uranium ore pulp flocculated with 0.23 lb of Separan 2610 per ton. The 30 pct solids pulp was flocculated with different concentrations of solution added in either one or three increments. The pulp was diluted to 16 pct solids after flocculation to insure identical conditions during determination of settling rates.

The advantages of dilute multiple point addition are quite pronounced, as these data show. However, the magnitude of this effect varies considerably from system to system. In one unusual case solid flocculant is added to a pulp[6] with good results.

Ease of reagent distribution varies markedly with the concentration and characteristics of the individual pulp to be flocculated. In general the more concentrated the pulp the more difficult distribution becomes. This fact is shown in Fig. 4, which summarizes tests in which various dilutions of the pulp used in previous tests were treated with 0.23 lb of Separan 2610 per ton, added as a 0.2-gpl solution in three increments. Initial settling rate was determined after dilution to 16 pct solids.

With most pulps, the effect of increasing the reagent dosage is to increase degree of flocculation. Fig. 5 illustrates the plateau reached with the addition of 0.2 lb Separan 2610 per ton. The same pulp was flocculated at 30 pct solids with varying amounts of flocculant diluted with a constant volume of liquor, so that the solids content of the pulp after flocculation was 16 pct in all cases.

At moderate levels polyacrylamide is almost quantitatively adsorbed by the solids. Non-adsorbed molecules do not remain in the liquid until amounts far beyond those required for effective flocculation are applied. This quantitative adsorption is, in part, responsible for the sensitivity of the flocs to more than mild agitation. When the flocs are degraded by mechanical agitation no unadsorbed flocculant is available and reflocculation does not usually occur, except to a small degree, until more is added to the system.

Sensitivity to agitation varies considerably from pulp to pulp. Fig. 6 shows the effect of agitation on one pulp, as well as the effect of additional reagent after extreme floc break-up. In these tests the 30 pct solids pulp was flocculated with 0.23 lb per ton Separan 2610 added as a 0.028-gpl solution in three increments. The pulp after flocculation contained 16 pct solids. One-liter portions of flocculated pulp were agitated with a 1½-in. four-bladed turbine

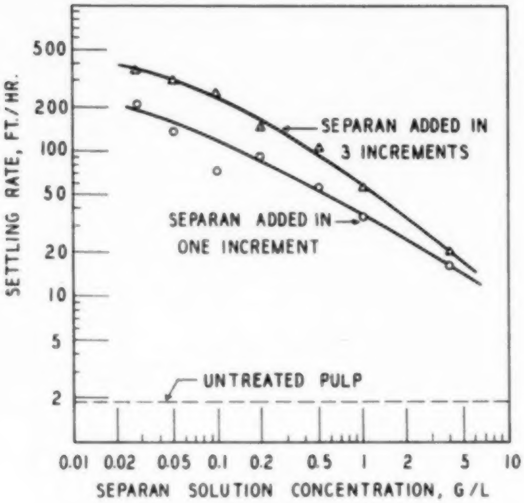


Fig. 3—Effect of Separan dilution on settling rate.

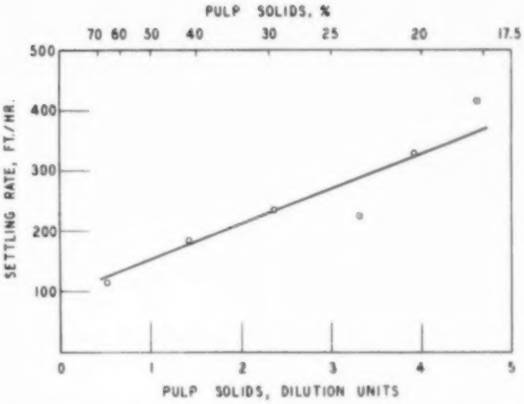


Fig. 4—Effect of initial pulp density on flocculation.

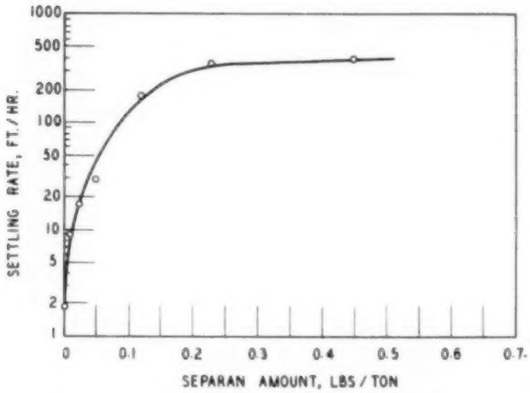


Fig. 5—Settling rate varies with amount of Separan.

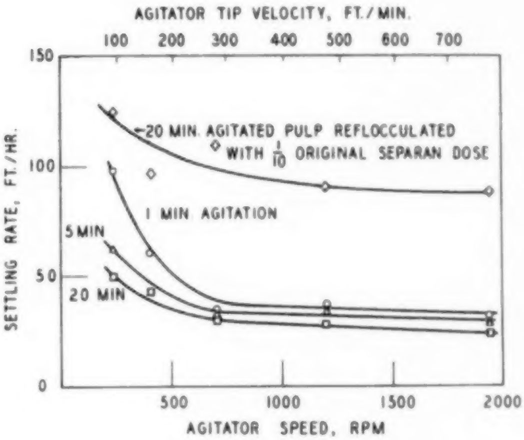


Fig. 6—Agitation of a flocculated pulp. (Unagitated rate: 460 ft per hr.)

type (Rushton) impeller in a 4-in. diam vessel 5 in. high, equipped with four baffles 0.4 in. wide. Settling rate of the pulp after agitation at various speeds and times was determined. The settling rate of the flocculated pulp agitated for 20 min and reflocculated with 0.023 lb per ton Separan 2610 added under the above conditions was also determined. In general, an agitation-degraded floc can be restored to its original flocculated condition by a small fraction of the original amount of reagent.

APPLICATION METHODS

In plant application the unique properties of polyacrylamide flocculants must be considered. It is generally impractical, because of the volume required, to prepare a solution at optimum application strength in a mixing tank, so a relatively concentrated (about 1 pct) stock solution is prepared and diluted continuously to the strength required. Laboratory tests should be made to determine the optimum concentration—usually less than 0.05 pct (0.5 gpl) is desirable.

It is often undesirable to add to the plant circuit the relatively large volume of water arising from the dilute reagent stream. Where this is true the stock solution is diluted to application strength with recycle plant solution, filtrate in a filtration operation, or thickener overflow in thickening or clarification. By this means solution at any concentration can be added without diluting soluble values. The stock solution should be prepared with water to eliminate the possibility of high viscosity, resulting from reaction of the flocculant with soluble iron or other ions.

At first glance, dilution of pulps with flocculant solutions might seem detrimental to liquid-solid separations but in clarification operations (very low pulp density) dilution is so small that this effect is not observed. In thickening operations, requirements are governed, not by the feed dilution, but by a more concentrated pulp zone in the thickener so that here, too, dilution has little adverse effect. In filtration a definite optimum reagent concentration will be found at which the increasing filtration rate result-

ing from an increased volume of the reagent solution is overcome by the decreasing filtration rate caused by pulp dilution. This effect is illustrated by Fig. 7, which shows the filtration of another 66 pct solids acid leached uranium ore pulp as a function of reagent dilution at two treatment levels. The pulp was flocculated by three increment additons, and filtration was determined on a 0.1-sq ft test leaf, with 35 sec submergence, 10 sec dry, 25 sec wash, 20 sec dry, and a 10-sec discharge cycle at 17-in. vacuum.

Optimum concentration is a function of the treatment level. Mechanical details of plant set-ups for using flocculants generally depend on problems of individual plants, and any discussion of application systems includes stock solution preparation, feed control and dilution, and application.

Importance of Thorough Dispersion: Fig. 8 illustrates two ways to obtain the even dispersion essential in preparing stock solutions of polyacrylamides. The first method uses high-power agitation (1.5 hp per 100 gal). The second adds dry flocculant to the tank through the Dow-developed Separan disperser, a water jet device. The dispersed solids are then dissolved by mild air or mechanical agitation for 1 to 2 hr.

Stock solutions are usually prepared in 50-lb increments (shipping bag size). Daily preparation is convenient, although polycrylamide solutions are stable for much longer intervals. Batch sizes as large as 1000 lb (12,000 gal of 1 pct solution) have been prepared in 2 hr.

LABORATORY METHODS

Preliminary laboratory tests are essential. Test work should simulate plant practice, using multiple point addition of a dilute solution. With thick pulps, such as those for filtration, this can be accomplished by dividing the dilute flocculant solution into three portions and simultaneously pouring together the pulp and successive portions of the solution with mild agitation between additions. In preparing more dilute pulps for thickening tests it is convenient to add reagent increments to the pulp in a graduate, gently rocking the graduate several times after each addition.

Laboratory filtration tests are usually carried out with standard test leaves. The filtration rate from a single test can be taken as the average of the rate calculated from the cake weight and that calculated from the filtrate volume. Alternatively, the filtration can be repeated on a batch of flocculated pulp until consistent cake weights and filtrate volumes are obtained.

As pointed out by Talmage and Fitch,[7] the classic Coe and Clevenger[8] thickening test method is not reliable when applied to flocculated pulps. This method necessitates determining settling rates of the pulp over a range of densities, but the problem of insuring the same degree of flocculation at the different densities is almost insurmountable. It might be attempted in two ways, flocculating the pulp at various dilutions or decanting varying amounts of liquid from a settled flocculated pulp and resuspending before it settles again. The data previously given prove the first method invalid, and the second is questionable because the flocs may have been compressed in settling or the agitation to resuspend the pulp may break up the floc. It should be noted that the Coe and Clevenger method generally gives settling areas greater than the true areas.

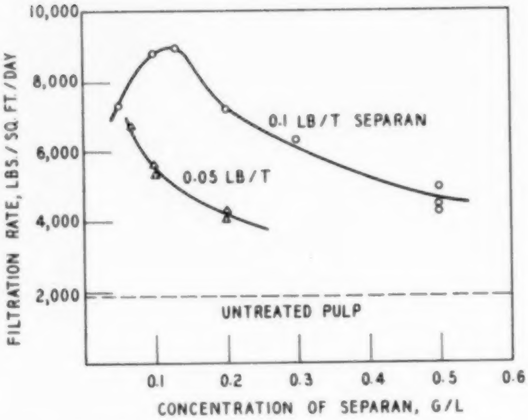


Fig. 7—Effect of Separan dilution on filtration rate.

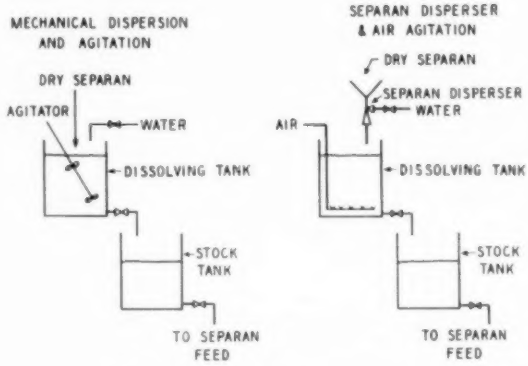


Fig. 8—Stock solution preparation.

At present there is no *completely* satisfactory thickening test for flocculated pulps, but the single-settling test developed by Talmage and Fitch, in conjunction with the compression point determination proposed by Roberts,[9] has been found useful and is probably as good as any method now available.

TYPICAL USES OF POLYACRYLAMIDES

The high-molecular weight polymers are remarkably versatile, flocculating a wide range of suspended solids, from coal and sewage to minerals and chemical precipitates. They are effective even when the suspending solution is strongly acid or basic or a strong salt solution. Particles ranging in size from colloidal clays to sands are flocculated by materials of this type.

Uranium Leaching: Leaching operations create some of the most difficult liquid-solid separations in the mining industry. Separan 2610 is used in uranium mills to thicken the ore pulp before leaching, to flocculate both acid and carbonate-leached pulp, and to flocculate high grade precipitates.[6, 10, 12] Hannay, for example, reports the use of 0.05 lb per ton of solids in ground ore thickening and 0.2 lb per ton to flocculate carbonate leach pulp before filtration.

Technical Note

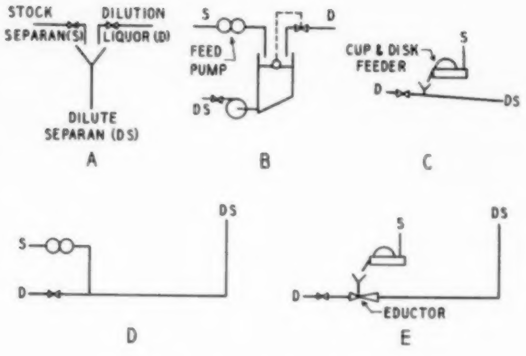


Fig. 9—Feed control and dilution.

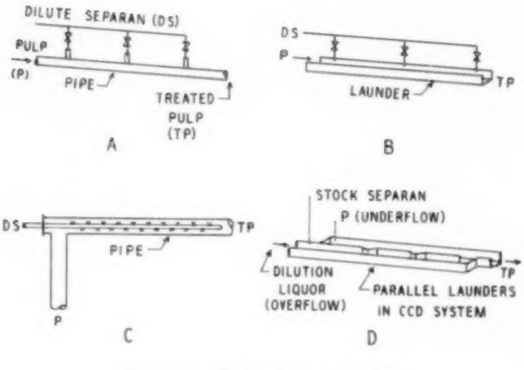


Fig. 10—Application to pulp.

Cyanidation, Zinc Leaching: Polyacrylamides are used extensively in gold cyanidation, which presents many problems similar to those of uranium leaching. They are effective on leached zinc calcines prior to electrolytic refining and recovery of the zinc and are also utilized in the neutral or primary leach thickeners, as well as in a number of thickening applications during purification of the zinc electrolyte. At Cerro de Pasco, Separan 2610 has been found to decrease zinc leach residue filtration time.[13]

Nickel Recovery: The study of flocculants made by Evans, Kunda, and Chiang[14] for Sherritt-Gordon's complex nickel recovery showed that 0.03 lb of Separan per ton of concentrate decreased the required thickener diameter from 103 to 73 ft on an ammonia leach slurry. In plant practice further capital expenditure for thickeners and filters was eliminated by using Separan 2610 at 0.03 lb per ton in the leach thickener, 0.06 lb per ton in the final thickener, and 0.12 per ton before final filtration.

Increased Tonnage without Expansion: Recognizing that dispersed pulp is desirable in flotation, operators naturally hesitated to use flocculants to thicken flotation feed. But laboratory results have indicated that where most of the mineral to be recovered occurs in the slimes, flocculants are not harmful and actually offer an advantage. Difficulties arise chiefly when slimes are mostly gangue minerals. When this occurs, flocculants may increase slime coatings on the minerals to be recovered and reduce concentrate grade or recovery.

By thickening flotation concentrates with flocculants, many plants have increased concentrate tonnage without expanding thickener capacity. Flocculant requirements for this purpose average 0.01 to 0.02 lb per ton.

To recover water and prevent stream pollution, it is increasingly important to thicken concentrator tailings. Polyacrylamide flocculants in tailings have improved operations without expenditure for additional thickeners. In several cases, flocculant is added directly to the tailing launder to facilitate dam building and obtain maximum clarity of tailing dam overflow.

Unique Application: Polyacrylamide flocculants have been used as electrolyte additives in refining and plating metals. One large copper refinery reports a 3 to 5 pct increase in current efficiency, as well as a smoother and higher-density copper deposit on the cathode. The additive's function in this application is apparently twofold. First, it effectively flocculates the slimes and causes them to settle to the bottom of the cell, eliminating the nuclei causing rough spots on the cathode. Second, the adsorption of the large molecule is concentrated at those points on the cathode which protrude toward the anode. This reduces current density at these points, rounding off the rough spots. A similar procedure is being investigated in zinc electrolysis.

Further Uses: Polyacrylamides are also effective in recovery of flue gas solids in scrubbing plants and removal of solids from the mine water before it is pumped. In areas where streams are unusually turbid, they are used to clarify the raw river water.

These applications by no means conclude the list. In almost every type of mining operation, polyacrylamide flocculants have improved thickening, filtration, and clarification. The increased capacity of liquid-solids separation equipment so obtained is having a pronounced effect on equipment and mill design.

The authors are indebted to E. C. Tveter and A. W. Hart for suggestions and editorial assistance in preparing this article.

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Discussion of this article sent (2 copies) to AIME before Feb. 28, 1959, will be published in MINING ENGINEERING.

bility of making use of this tendency for the con-

Tests 108 and 114 show results on undecomposed

BENEFICIATION OF AUTUNITIC ORES

Experiments have developed a highly successful collector for this mineral component of a low grade uranium ore.

By WILLIAM C. AITKENHEAD and JOHN A. JAEKEL

Uranium deposits in the Spokane Indian Reservation, as well as those around Mt. Spokane, are essentially low grade, much of the ore containing less than 0.2 pct U_3O_8. The Mining Experiment Station of the Division of Industrial Research, State College of Washington, has been engaged in intensive research on the amenability of these low grade ores to froth flotation. The results: successful flotation of autinite, chief mineral constituent.

At the outset of this work the goal was a concentrate of 1 pct U_3O_8 with a 90 pct recovery from ores containing less than 0.2 pct U_3O_8. Most of the work has been done on argillite ore from the Midnight mine on the Spokane Indian Reservation. The goal has not been attained using this ore, but samples of the granite ore from Mt. Spokane yielded successful results. For example, a concentrate containing 11.2 pct U_3O_8 was produced from a Mt. Spokane high grade ore containing 1.27 pct U_3O_8, with a recovery of 97.8 pct. Another Mt. Spokane ore yielded a concentrate of 5.0 pct U_3O_8 from an ore containing 0.13 pct U_3O_8, with a recovery of 85 pct. This same ore gave a recovery of 93.5 pct when the grade of concentrate was reduced to 2.0 pct.

It has been concluded that a successful method for floating autunite has been developed and that the mediocre results from the Midnight argillite ore are probably caused by the presence of some other uranium mineral or minerals less amenable to these reagents.

The experimenters tested a third type of Washington ore, found on the Northwest Uranium Mines Inc. property on the Spokane Indian Reservation. This is a conglomerate of pebbles and small boulders of partially decomposed granite and is shot through with autunite. Its characteristics lie between those of the Midnight ore and the granite ore from the Spokane district. It responds better than the ore from Midnight but not as well as that from Mt. Spokane.

As the fatty acids are the only type of collectors showing promise, investigation has been concerned with these acids and the optimum conditions for their use. The first method for treating the argillite ore from the Spokane Indian Reservation made use of Cyanamid's R-708 as a collector, a tall oil product described as a substitute for oleic acid. Although the investigators proved that R-708 is a collector for autunite when mixtures of autunite and silica sand are used, results on the ore were mediocre. Tests of other fatty acids revealed that the solid fatty acids of the saturated series are collectors for autunite and that their collecting power increases with the length of the carbon chain. The even carbon members of the whole series were tested from the 10 carbon acid (capric) to the 22 carbon acid (behenic). The least expensive collector, stearic acid (18 carbon), proved to be a good one, so this was used in most of the tests.

In first attempts with stearic acid, the collector was dissolved in various hydrocarbons and the solutions were added to the flotation cell. Cyclohexane, gasoline, fuel oil, kerosene, and other solvents were tried. Small amounts of high grade concentrates could be brought up, but recoveries were low. Finally emulsions of stearic acid were tried. It was discovered that stearic acid alone has little collecting power except when conditioning is carried out at high temperature. When hydrocarbon solvents were also present, it proved to be an excellent collector. An example of one emulsion that proved satisfactory for some ores is given as follows: 1 part stearic acid by weight, 1 part sodium oleate by weight, 1.2 parts kerosene by weight, 100 parts water. In some successful tests part of the stearic acid was replaced by oleic acid.

The emulsions were made by agitating the stearic acid and sodium oleate together with hot water, then adding the kerosene and agitating while cooling.

In the five tests reported in Table I, 650 g of ore were ground with 650 cc water in a laboratory rod mill. The pulp was filtered to eliminate excess water and the ground ore transferred to a stainless steel beaker for conditioning at high pulp density. In most of the tests sodium hydroxide was added to the conditioner during agitation, then the collector emulsion, and finally the sodium silicate. The amount of alkali was adjusted to give a pH of 8.5 to 9.0 in the flotation cell. After conditioning the pulp was transferred to a laboratory flotation cell and the test completed in a normal manner.

It is interesting to note that a deposit of high grade concentrate forms on the conditioning agitator and in the conditioning vessel, and at times on the agitator of the flotation cell itself. A few grams of concentrate running as high as 4 pct U_3O_8 were recovered from the conditioner when Midnight ore containing less than 0.2 pct U_3O_8 was treated. In the examples given in Table I this conditioner concentrate is calculated as part of the total concentrate. The authors have not yet fully explored the possi-

W. C. AITKENHEAD and J. A. JAEKEL, Members AIME, are, respectively, Director and Metallurgist, Mining Experiment Station, State College of Washington, Division of Industrial Research, Pullman, Wash. TN 463B. Manuscript, May 26, 1958. AIME Trans., Vol. 214, 1959.

bility of making use of this tendency for the concentrate to stick to metallic surfaces.

Table I reports details of tests on five ores. Test AU 185 shows results on a sample of low grade Midnight argillite ore, the most difficult of all ores tested. Concentrates from this ore always contained large amounts of ferruginous slime and decomposed biotite mica, so the concentrate grade was invariably low. Low recoveries may have been due to nondescript uranium minerals in the extremely fine sizes.

Test 140 records data on a conglomerate ore, which gave results better than those obtained on the Midnight sample, but inferior to the good recoveries with high grade concentrates that result from the Mt. Spokane granite ores.

Tests 108 and 114 show results on undecomposed granite ore from Mt. Spokane. Test 116 treated a decomposed granite ore in which the feldspar was largely kaolinized. The clay in this ore does not interfere with production of high grade concentrates with good uranuim recovery.

Table II shows results of tests for maximum recovery compared with tests for maximum grade of concentrate.

Use of the stearic acid-kerosene emulsion has not been investigated as a collector for other uranium minerals more common than autunite. So far there have been no studies of concentrate cleaning and recirculation of the cleaner tailings, which should give a higher grade concentrate with little or no sacrifice of recovery.

Table I. Test Results for Five Uranium Ores

Test Factors	Test AU 185 Dawn Mining Co. (Midnight Ore) 0.12 Pct U_3O_8 −35 Mesh	Test No. 140 N.W. Uranium Inc. 0.148 Pct U_3O_8 −48 Mesh	Test No. 108 Mt. Spokane (Granite) 0.215 Pct U_3O_8 −35 Mesh	Test No. 114 Mt. Spokane (Granite) 0.390 Pct U_3O_8 −35 Mesh	Test No. 116 Mt. Spokane (Decomposed Granite) 0.131 Pct U_3O_8 −48 Mesh
Conditioning Reagents, Lb Per Ton					
NaOH	1.2	—	0.3	0.15	0.15
Collector emulsion					
Stearic acid	1.5	1.5	2.25	1.0	1.5
Oleic acid	1.5	—	—	—	—
Sodium oleate	3.0	1.5	2.25	1.0	1.5
Kerosene	2.4	1.2	4.8	1.1	1.7
Sodium silicate	—	0.3	0.3	0.3	0.3
Sodium metasilicate	1.2	—	—	—	—
Pulp density, pct	59	59	61	61	60
Temperature, °C	24	28	29	29.5	26.3
Time, min					
NaOH	26	25	21	21	21
Collector emulsion	20	20	20	20	20
Sodium silicate	—	2	2	2	2
Sodium metasilicate	26	—	—	—	—
Flotation Reagents, Lb Per Ton					
B-23	—	—	0.2	0.3	0.35
Pine oil	—	0.18	—	—	—
Collector emulsion*					
Stearic acid	—	1.5	—	—	—
Sodium oleate	—	1.5	—	—	—
Kerosene	—	1.2	—	—	—
Temperature, °C	24	27	26	26	26
pH	8.3	8.15	9.0	9.0	8.7
Pulp density, pct	19.0	25	25	25	25
Recovery, pct	75.7	89.6	95.0	89.3	93.5
Concentrate, pct U_3O_8	0.434	0.44	3.06	12.04	2.0
Ratio of concentration	4.8	3.3	14.9	34.6	16.5
Tailings, pct U_3O_8	0.037	0.022	0.011	0.043	0.009
Total reagent cost per ton, $	1.13	1.09	0.84	0.40	0.56

* Four-stage additions.

Table II. Recovery vs Grade

Objective	Test No.	U_3O_8, Pct Heads	Recovery	Concentrate	Tails	Ratio Conc.
Ore from Daybreak Mines Inc. (Mt. Spokane)						
Maximum recovery	AU 230	0.125	96.6	0.87	0.006	7.1
Maximum recovery	116	0.131	93.5	2.00	0.009	16.5
Maximum grade	116-b	0.131	85.0	5.00	0.020	45.1
Ore from Mt. Spokane (Granite)						
Maximum recovery	108	0.215	95.8	2.29	0.010	11.2
Maximum recovery	109	0.226	94.3	2.70	0.014	12.7
Maximum grade	111	0.348	83.3	19.4	0.059	67.0
Maximum grade	114	0.390	89.3	12.0	0.043	34.6
Recovery and grade	113-b	0.385	93.1	6.0	0.028	16.8
Ore from Mt. Spokane (Decomposed Granite)						
Maximum recovery	93	1.40	98.6	7.0	0.026	4.8
Maximum grade	92	1.27	97.8	11.2	0.032	9.0
Ore from Northwest Uranium Mines Inc. (Conglomerate)						
Maximum recovery	140	0.148	89.6	0.44	0.022	3.3
Maximum grade	140-b	0.148	80.1	1.14	0.033	9.6

shaped bit. The events may be summarized briefly as follows, with reference to Fig. 1:

1) Crushing of surface irregularities as bit first

at the tip of a crack, causing it to propagate and the material to rupture at loads only a fraction of the cohesive (compressive) strength. Griffith's mathe-

BASIC STUDIES OF PERCUSSION DRILLING

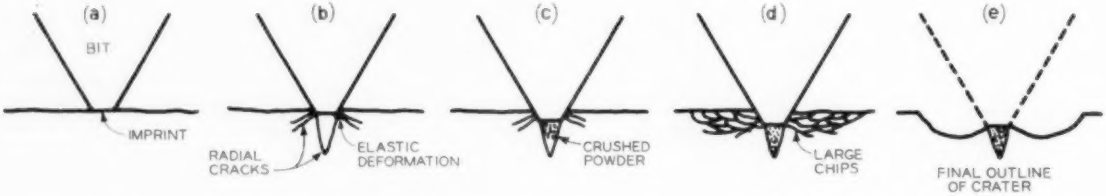

Fig. 1—Sequence of rock failure and crater formation when a blunt, wedge-shaped bit strikes an impact blow.

The author contends that for more than 70 years there has been no major improvement in percussion drills, that rock drilling remains an art when it should become a science, and that faster rates of penetration depend on advances in basic research.

BY HOWARD L. HARTMAN

The past 15 years have seen rapid advances in the metallurgy of materials for drill machinery and bits, but rock drilling itself continues to be largely an art. Jet piercing, roller bit rotary drilling, and rotary percussion are all promising new techniques, but the percussion rock drill, still used for 90 pct of the blastholes in U. S. hard-rock mining, has undergone no major modification since pneumatic machines were first used successfully in the 1860's.

This singular lack of progress stems directly from ignorance of the nature of impact failure of rock and the fundamentals of rock penetration in general. For nearly three-quarters of a century, mining engineers did not know what went on at the bottom of a drillhole.

More and more, in recent years, investigators in the field have come to realize that to understand percussion drilling they must study the basic action of percussion bits penetrating rock—not the performances of commercial rock drills, with their many attendant variables that cannot be isolated or controlled.

Using a vertical drop tester, the writer investigated the sequence of rock failure under the impact of a simple, chisel-shaped bit when changes were made, singly, in significant variables. Results of this and other research are reported here.

BASIC CONCEPTS

The formation of a crater in rock under the impact blow of a bit can be observed experimentally. Directly beneath the edge of the bit the rock is crushed into fine powder; toward the sides of the crater it chips out into relatively large fragments.

An explanation of these phenomena has been offered by Drilling Research Inc. on the basis of work sponsored by this organization at Battelle Memorial Institute (Ref. 1, 1954, Summary, pp. 9-18). High-speed photography and force waveforms obtained from strain gages mounted on the bit near the cutting edges recorded the sequence of events in crater formation with a die-shaped or blunt, wedge-

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shaped bit. The events may be summarized briefly as follows, with reference to Fig. 1:

1) Crushing of surface irregularities as bit first makes contact with rock.

2) Elastic deformation of rock from continued application of load by bit. Subsurface cracks radiate out from lines of stress concentration at boundaries of cutting edge; two major cracks propagating downward converge and outline V-shaped wedge.

3) Crushing of central wedge of rock into fine fragments.

4) Chipping out of large fragments along curved trajectory to surface adjacent to crushed zone.

5) Crumbling away of crushed zone and displacement by bit as it continues to penetrate. Entire sequence may be repeated if blow energy is sufficient.

With a sharp, wedge-shaped chisel bit the same phenomena of rock failure are evident as with the die-shaped bit, but essentially they occur simultaneously instead of successively. The crushing and chipping processes follow many times in succession, almost continuously, until the blow energy is dissipated. The outward appearance of the crater is the same, but somewhat less subsurface damage (fracturing, cracking, and crushing) occurs.

Crushing vs Chipping: In the DRI discussion of crater formation, it was pointed out that some of the rock was displaced by crushing and some by chipping. It has long been maintained that in percussion drilling the fastest penetration is attained when the greatest proportion of chipping to crushing takes place. Basic energy relations can be used to demonstrate that the most efficient drilling is accompanied by the fewest and coarsest cuttings per unit volume.[2]

Consider a wedge-shaped bit. The predominance of crushing or chipping depends chiefly on the included angle of the wedge—more crushing and less chipping occurs as the cutting angle of bit increases. More of the compressional loading applied to the rock by the bit with an obtuse-angled wedge is directed downward, so that higher forces are needed for fracturing chips to surface. The area of contact between bit and rock is larger for a given depth of penetration, also necessitating higher forces to deliver the same stress to the rock. In practice, bits with included angles over 90° produce relatively little rock damage by chipping. For that reason, acute-angled bits are definitely preferable from the standpoint of drilling speed, although they wear more rapidly.

Two investigators (Ref. 1, 1953, 2nd Qtr., pp. 11-14; Ref. 3) have reported that at constant blow energy, depth of penetration of the bit varies inversely as the square root of the tangent of half the wedge angle, and the area or volume of the crater formed is a function of the reciprocal of the tangent of half the wedge angle.

Mechanism of Rock Failure: Rock failure under an impact blow appears to be related to the number and magnitude of local flaws or cracks in the rock structure and to their distribution geometrically about the line of load. As the bit penetrates the crushed zone, stresses build up in the adjacent *solid* rock until a crack propagates from one of the points of stress concentration and a chip is formed.

Griffith[4] states that failure of brittle material, such as rock, under a compressive load actually occurs in tension, along cracks or planes of weakness oriented at 45° to the axis of load. Stress tends to concentrate at the tip of a crack, causing it to propagate and the material to rupture at loads only a fraction of the cohesive (compressive) strength. Griffith's mathematical deductions, based on the theory of elasticity, may be applicable to rock penetration under impact, although his work is theoretically correct only for static loading conditions.

Mathematical Analysis of Effect of Bit Shape on Penetration: It is highly desirable to obtain a mathematical relation between energy of blow and depth of penetration, cross-sectional area, or volume of

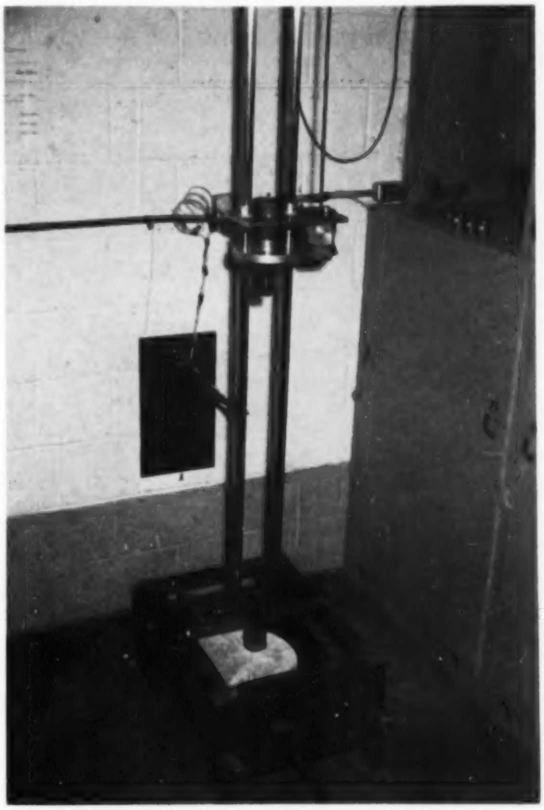

Fig. 2—The laboratory drop tester. The plate with the attached bit and the weights is held by the triggering device, ready for a drop onto the test rock below.

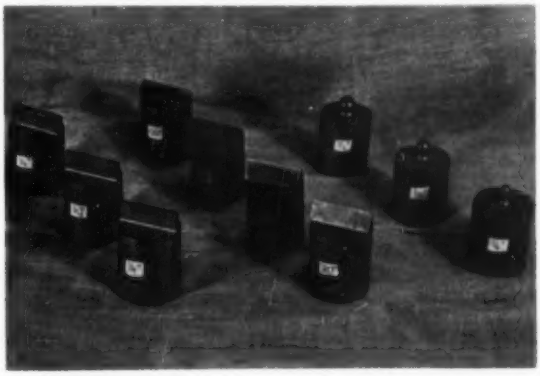

Fig. 3—Various bit shapes used in the experimental work. Left, die; center, wedge; right, hemisphere.

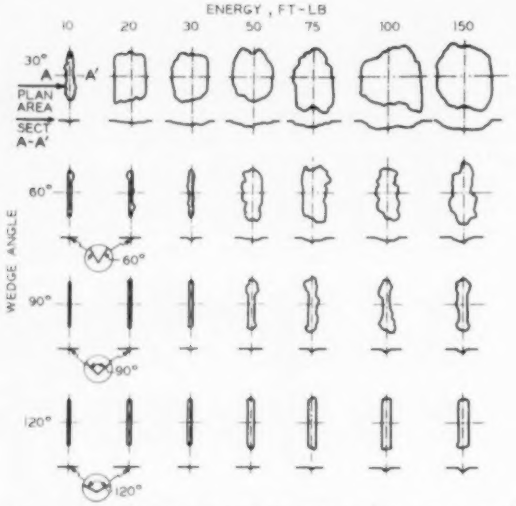

Fig. 4—The shapes of typical craters that are formed by sharp, wedge-shaped bits with varying blow energy.

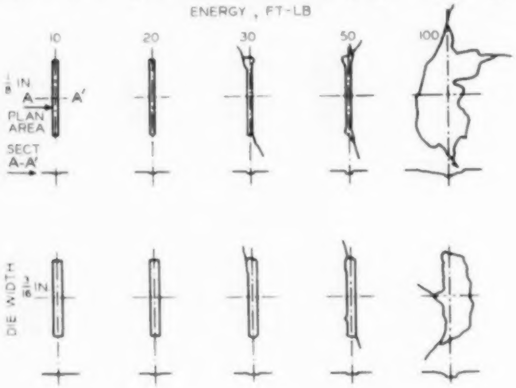

Fig. 6—The shapes of typical craters that are formed by die-shaped bits striking with varying blow energy.

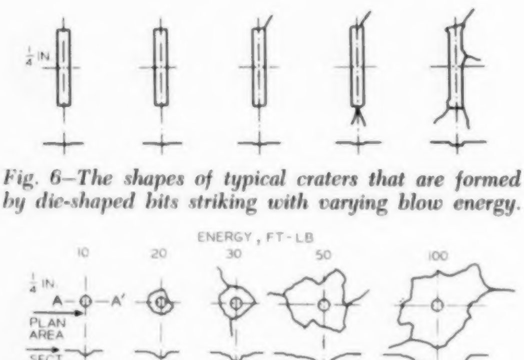

Fig. 7—The shapes of typical craters formed by hemispherical-shaped bits striking with varying blow energy.

crater for any shape of bit. This relationship is needed to determine an expression for the rate of penetration of a drill bit, since the amount of rock broken out per blow per unit of time is a measure of drilling speed.

The approach adopted here was suggested by Drilling Research Inc. (Ref. 1, 1953, 2nd Qtr., pp. 14-18) for die and wedge-shaped bits. Although over-simplified, it is believed to indicate the basic relationship between blow energy and crater dimensions. The author independently arrived at the same relation for the wedge-shaped bit, which led him to extend the derivation to other bit shapes.

Consider a chisel bit of any shape. The resistive force the rock offers to bit penetration is assumed to act over the horizontal projection of the area of contact of bit and rock, the area being a function of depth of penetration for that particular shape of bit. Let the unit resistance of the rock to penetration be f and the horizontal projection of the area be a. Then the work, w, in penetrating the rock is a function of the force developed, F ($=fa$) and the depth of penetration of the bit, h, or

$$w = \int_0^h F\,dh \qquad [1]$$

At the maximum depth penetrated, the work done is equal to the energy of the blow, E. After substituting fa for F (with a a function of h) and setting the equation equal to E when integrating, the expression can then be solved for h in terms of E.

The procedure is demonstrated below for the wedge, a typical bit shape:

Let l = length of cutting edge and
θ = included angle of wedge;
then $a = 2\,lh \tan \theta/2$ and
$F = fa = 2flh \tan \theta/2$;
therefore, $w = \int_0^h 2flh \tan \theta/2\,dh$.
Integrating, $E = flh^2 \tan \theta/2$

and

$$h = \sqrt{\frac{E}{fl \tan \theta/2}} \qquad [2]$$

This relation demonstrates theoretically that the depth of penetration is inversely proportional to the square root of the tangent of half the wedge angle, *but more important, it shows that the depth varies directly as the square root of the blow energy*, or $h \propto E^{1/2}$. Further, it can be shown that since l is independent of h and since the cross-sectional area of the crater varies as the square of h, *the volume of the crater V is directly proportional to the blow energy:* $V \propto E$. This demonstrates the dependence of crater formation on blow energy.

This expression is of tremendous importance in determining and explaining percussion drilling performance. It can be shown mathematically that *the above relation between V and E should be valid for any shape of bit*: wedge, die, blunt wedge, cylindrical, conical, prismatic, or hemispherical.

One reason this relationship is over-simplified is that a threshold energy E_o exists below which only elastic deformation occurs and no damage is done to the rock. A more correct version of the above expression is then:

$$V \propto (E - E_o).$$

E_o is almost negligible for sharp wedges or soft rocks but may be rather large for blunt bits or hard rock.

Within limits, the experimental work will be shown to substantiate this theory.

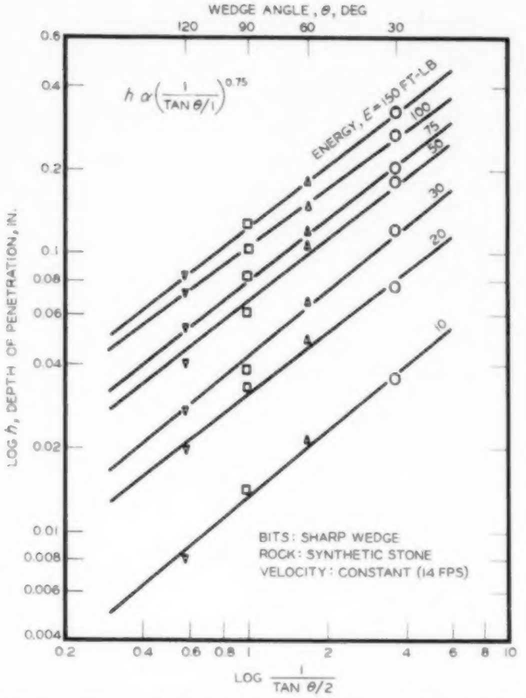

Fig. 5—Effect of included angle of cutting edge (wedge angle) on penetration depth of sharp, wedge-shaped bits.

Blow Dynamics: Those factors in drilling which can be grouped under blow dynamics include: 1) energy, 2) velocity, 3) mode of transfer, 4) force, 5) contact time, 6) momentum, 7) impulse, and 8) acceleration. All these factors may influence rock failure and crater formation and hence rate of penetration in drilling. The first three are reported experimentally in this article.

The most significant dynamic factor is blow energy; the importance of blow velocity is debatable. Battelle (Ref. 1, 1953, 3rd Qtr., p. 7) and Shepherd[5] have reported a negligible effect of this variable on crater formation, while Freudenthal (Ref. 1, Oct. 15, 1952, pp. 20-37) claims an inverse relationship. Shepherd's work, however, was apparently complicated by down-hole conditions, and the velocity and energy ranges of the two DRI studies were too limited.

The different principles involved in transferring the impact of a percussion blow are demonstrated by the old piston machine and the present hammer drill. Coupling of the piston and steel is an important consideration with the hammer principle, and elastic waves set up in the steel may aid or hinder penetration. On the other hand, the piston drill must overcome higher inertias as the steel length or size increases. Mode of blow transfer has never received adequate study.

Multiple Blows: The relationship of adjacent blows to crater formation and rate of penetration is complex. A study of single unrelated blows logically progresses to consideration of multiple blows struck a given, indexed distance apart. In a conventional rock drill using a radial-wing bit, indexing is achieved by rotating the steel and bit through a prescribed arc.

Rock breakage is substantially increased by the existence of an additional free-face to break to when adjacent craters are close enough together to cause crater 2 to break into crater 1. Theoretically, the maximum effect is realized when the indexing distance is at an optimum. When the indexing is less than optimum, energy is wasted and the average crater volume diminishes; when the indexing is greater than optimum, the craters will not break into one another and the average volume is the same as for an individual blow.

Drilling Research Inc. devoted considerable study to this factor (Ref. 1, Summary, pp. 25-33; Ref. 6). DRI's so-called *universal indexing curve*, based on drop tester studies, indicates that the average volume of rock per blow is independent of the indexing distance, provided that distance exceeds a minimum value. In an actual drilling process with a radial-wing bit, indexing has much less influence, because multiple wings form W craters per blow, and there are then W craters to break to after only $1/W$ rev of the bit (where W is number of bit wings). Almost infinite statistical variations in the indexing distance are encountered after $1/W$ rev, which complicates theoretical analysis. Experimental work on this factor will be reported later.

Rate of Penetration: The ultimate goal of fundamental studies of rock drilling is to achieve faster rates of penetration by increasing knowledge of the basic mechanism of rock penetration. Another objective is to predict or calculate rates of penetration from basic parameters of the process.

To date there have been two formulas developed to express the linear rate of penetration, S, of a multi-wing chisel bit. One, reported by Simpson and Parry,[7] is in terms of the average distance of advance, d, of the bit per blow:

$$S = \frac{WdB}{B/R} = WdR \qquad [3]$$

where R is frequency of rotation and B is frequency of reciprocation. A second, proposed by Battelle (Ref. 1, 1954, Summary, pp. 3-5), involves the average cross-sectional area of crater A broken per wing at the periphery of the bit:

$$S = \frac{WAB}{\pi D} = \frac{WAB}{C} \qquad [4]$$

where D is gage (diameter) and C is circumference of bit. Actually, both expressions are equivalent, because $d = (A/C)\ (B/R)$.

Still a third and more useful expression may be obtained from Eq. 3 or 4 relating S and the volume of crater V broken per wing by any chisel-shaped bit:

$$S = \frac{W \dfrac{4V}{D} B}{\pi D} = \frac{VBW}{A_b} \qquad [5]$$

where $A = 4V/D$ and $A_b = 1/4\pi D^2$ is plan area of the bit (or hole, more correctly). Recalling that $V \propto E$ for any shape of bit (actually, WV and E, considering the bit as an entity), then

$$S \propto \frac{BE}{A_b}.$$

Thus, *energy of blow, frequency of blows, and plan area of bit are the principal variables on which rate of penetration depends.*

It is definitely an advantage that with all three formulas the crater dimension (h, A or V) can be determined experimentally, probably by drop tester.

Simon[8] has also obtained an experimental relation between rate of penetration and power, P, of a drilling process:

$$S = 2.4 \frac{P - P_o}{D^2 c} \qquad [6]$$

where P_o is threshold power and c is drilling strength of the rock. Note the similarity between the last two formulas. Since $P = BE$ for a percussion drill, it can be shown by either relation that

$$S \propto P$$

or, *the rate of penetration is directly proportional to the power of the process.* This is a basic premise of percussion drilling.

Experimental evidence from actual drilling has been offered by several investigators[2,8,9] to confirm this relation. As mentioned before, evidence from drop tests will be offered to verify the relation $V \propto E$, which then may be considered substantiation of the $S \propto P$ expression.

EXPERIMENTS WITH DROP TESTER

The principal laboratory equipment used in carrying out the present investigations was an impact drop tester (Fig. 2), calibrated to obtain a wide range of blow energy, velocity, and load. Bits of the desired shape (Fig. 3) were attached to a weighted plate and permitted to strike blows on rock specimens. Synthetic stone was used for the entire series of tests, prepared from high, early-strength cement and FF-grade pumice in a 4:1 weight ratio that averaged 5000 psi compressive strength. The use of synthetic stone reduced the effects of heterogeneity and variability between specimens and still faithfully demonstrated the mechanism of failure in rock types such as shale, siltstone, and the younger sediments whose behavior is termed both brittle and ductile.

Before each test, the rock specimen was clamped in the position desired for receiving the blow. The height of fall to produce the required velocity and energy of blow had been previously calculated and the plate was raised to that height. A cardboard cylinder was placed on the rock at the location of the intended blow to prevent scattering of cuttings. Then with the desired bit attached to the plate, the blow was struck.

All dimensions of the resulting crater were determined, either by direct measurement or by calculation, as follows:

1) Weight of cuttings, by direct weighing.
2) Volume of crater, by weight of dental wax required to fill the impression, converted to volume.
3) Depth of crater, by micrometer depth gage.
4) Length of crater, by scale.
5) Plan area of crater, by planimetering the outline traced on paper.
6) Width of crater, by calculation (the plan area divided by the length).
7) Cross-sectional area of crater, by calculation (the volume divided by the length).

In addition to dimensions, observations on crater formation were recorded with each series of drops. The cross section of each crater was sketched, and notes were made on chipping, crushing, and cracking.

At least ten tests were carried out at each level of variable studied. Results of the acceptable tests were averaged together, while those affected by cracks from other craters, the edges of the rock, or imperfections in the rock were discarded. (About one in ten was not acceptable.) Even with all precautions, variations up to 50 pct were noted in data from ten tests, ample evidence that: 1) even synthetic rock is lacking in homogeneity, and 2) brittle failure is complex and non-uniform.

Tests on the following variables in rock penetration were conducted in the manner indicated:

1) Blow energy varied from 10 to 150 ft-lb for wedge-shaped bits of included angle 30° to 120°, and from 10 to 100 ft-lb for die-shaped bits ⅛ to ¼ in. wide and hemispherical bits ¼ to ½ in. diam; blow velocity was 14 fps.

2) Blow velocity varied from 8.6 to 20.4 fps for 30° wedge-shaped bits and blow energy was 22.2 ft-lb.

3) Mode of blow transfer varied with bit in motion or bit at rest; wedge angle was 30° and blow energy 30 ft-lb.

4) Indexing studies were conducted with blows struck on previously cratered surface, wedge angle 30°, blow energy 30 ft-lb, and indexing 1 in.

DISCUSSION OF TEST RESULTS

Bit Shape, Wedges: The importance of the included angle of sharp, wedge-shaped bits on crater formation was confirmed. As the blow energy was varied with bits of different angles, two separate and distinct phases in the cutting action were observed, namely, the crushing and chipping phases. This behavior can be seen in the sketches of typical craters, appearing in Fig. 4, which may be summarized as follows:

1) Both crushing and chipping were not obtained with all wedges—the 30° wedge always penetrated by chipping, whereas the 90° and 120° wedges never left the crushing phase, even at high blow energies.

2) Craters were formed principally by crushing *or* chipping; some chipping occurred when crushing was predominant (particularly at the ends of the pit) and crushing continued even after chipping began, but there was a fairly sharp demarcation in cutting.

3) Chipping did not predominate until a certain energy level was attained; this was low with the 30° bit and apparently infinite with bit angles greater than 90°.

4) There was similitude in the crushing or chipping phase for a given bit, although at the highest blow energies (150 ft-lb) the craters appeared to deepen with little or no increase in volume.

The relationship between depth of penetration and wedge angle was determined by plotting a family of curves at constant energy (Fig. 5). The slope of the straight lines obtained indicated that

$$h \propto \left(\frac{l}{\tan 0/2}\right)^{0.75}.$$

This deviates somewhat from the square-root relation expected, indicating that the earlier explanation is over-simplified. Likewise, the relation between the volume of crater and the function $\frac{l}{\tan 0/2}$ was exponential to the power 1.5 instead of 1.

Dies and Hemispheres: The other two shapes of bits behaved in a manner similar to that of the wedge. The appearance of the craters (Figs. 6 and 7) revealed a predominance of either crushing or chipping at various energy levels, although the transition between the two phases was less sharply de-

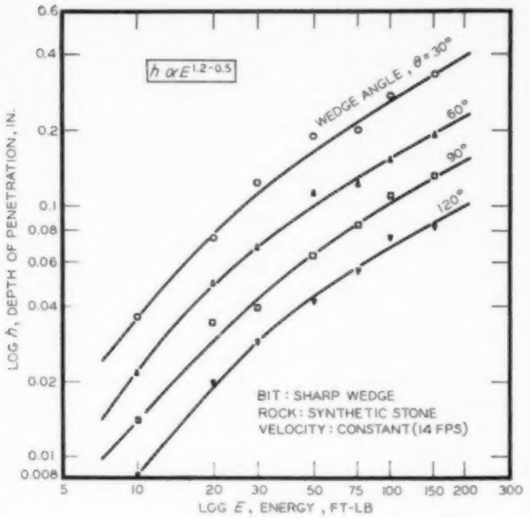

Fig. 8—Plotted results show effect of energy of blow on depth of penetration of sharp, wedge-shaped bits.

fined. More radial cracking was observed with these bit shapes than with the wedges, indicating a proportionately higher expenditure of energy for cracking than for crater formation. There was a strong tendency with both dies and hemispheres for adjacent craters to index across at higher blow energies. Rebound was not significant (less than 1 pct) with any bit shape.

Blow Energy, Wedges: The depth of penetration of sharp, wedge-shaped bits was plotted against energy of blow (Fig. 8). Again, some departure from theory was evident, because this relation varied from $h \propto E^{1.2}$ at low energies to $h \propto E^{0.5}$ at high energies. The varying geometry of the falling mass as well as end effect (due to inconstant crater length) probably were responsible for some of the variation in slope of this family of curves.

For the 90° and 120° bits, the length of crater l varied with energy to the 0.03 and 0.05 power, respectively: $l \propto E^{0.03 \text{ or } 0.05}$. The exponent varied from 0.05 to 0.15 for the 60° bit and 0.05 to 0.25 for the 30°. At low energies, length is nearly constant, but at high energies it increases significantly for acute-angled bits.

Volume of crater plotted against energy of blow (Fig. 9) indicated that $V \propto E$, approximately, in either the crushing or chipping phase. This is an important confirmation of theory. Two phases, crushing and chipping, were evident, which partly explains why these data fluctuate more than the values for depth of penetration. With all the bits tested, there was some indication that when blow energy is increased beyond a certain point the benefit decreases, i.e., the crater volume appears to taper off at 150 ft-lb. More longitudinal cracks and subsurface damage appeared to accompany high-energy blows, however, and there was more tendency for craters to index across, which may compensate for the crater volume.

Divergence in crater similitude for a given wedge angle can be ascertained by comparing the effect of blow energy on other crater dimensions. Cross-sectional area, like volume, varied directly as blow energy $A \propto E$, approximately, with sharp breaks between the crushing and cutting phases. However, the

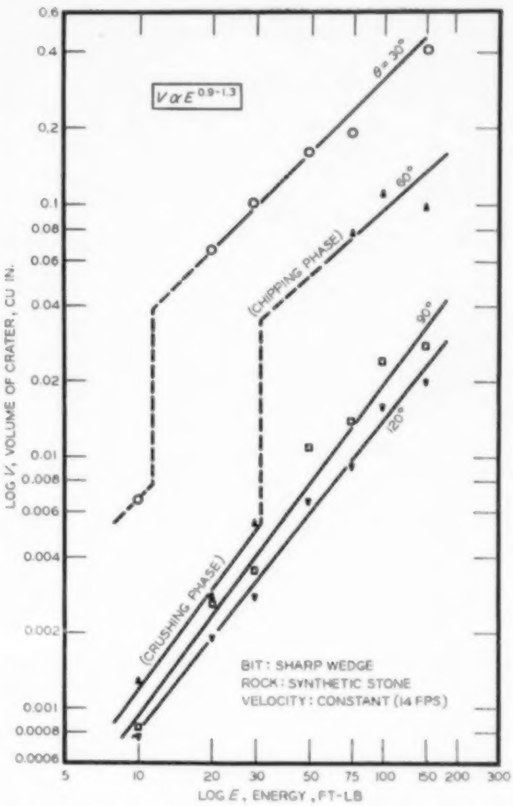

Fig. 9—Effect of energy of blow on volume of the crater that is formed by sharp, wedge-shaped bits.

Fig. 10—The effect of energy of blow on volume of the crater that is formed by die-shaped bits.

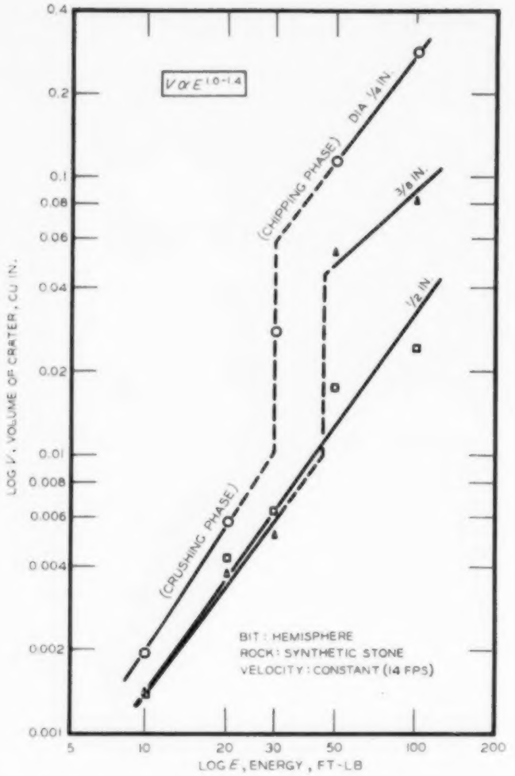

Fig. 11—The effect of energy of blow on volume of the crater that is formed by hemispherical-shaped bits.

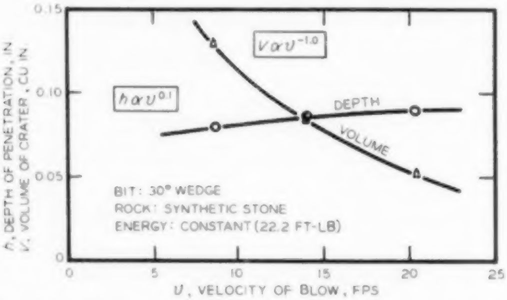

Fig. 12—Effect of velocity of blow on penetration depth and volume of crater formed by 30° wedge-shaped bit.

plan area of the crater A_p (as well as the width b) varied with energy approximately to the 0.6 power, or

$$A_p \propto b \propto E^{0.6}.$$

Again, the different cutting actions were plainly visible. These relations confirm the earlier observation that as energy rises the crater increases less rapidly in plan dimensions than in depth. With all crater dimensions except depth, there was a marked tendency to level off or even decrease at high blow energies.

Dies: The effect of blow energy on the depth of penetration of die-shaped bits only approximated the linear relation anticipated: $h \propto E^{1.8}$. The variation of volume of crater with energy (Fig. 10) agreed somewhat better with theory, because $V \propto E^{1.2}$, approximately.

Hemispheres: The hemispherical bits also departed from theory in the behavior of depth of penetration with varying energy. The data demonstrated that $h \propto E^{0.9}$, rather than the cube-root relation that would be expected. Again, the crater volume showed closer conformity because, as illustrated in Fig. 11, $V \propto E^{1.2}$.

It is very significant that for all three bit shapes tested—the wedge, die, and hemisphere—an essentially linear relationship between volume of crater and energy of blow was obtained for the crushing and chipping phases, in spite of variance in h vs E. *This is an important verification of the theory advanced earlier.*

Blow Velocity: Studies of blow velocity carried out with the 30° wedge at constant blow energy indicated diverging trends of h and V (Fig. 12). Depth of penetration remained practically constant over a wide range of velocity, v: $h \propto v^{0.1}$, while volume of crater varied inversely with velocity: $V \propto \frac{l}{v}$. Furthermore, while the length of crater remained constant, the plan area also fell off as velocity increased:

$$A_p \propto \frac{l}{v^{0.6}}.$$

These three relations indicate that a very definite change was taking place in the cross section of the crater as the velocity was varied over the range (8.6 to 20.4 fps) studied. While the depth was practically unchanged, the craters appeared to narrow and developed less of a U-shape and more of a V-shape. At least for this bit shape, blow energy, and rock type, an increase in blow velocity proved detrimental to crater formation. The effect of this variable is complicated by the interaction of contact time and the geometry of striking mass, however.

Blow Transfer: As the following data show, crater formation was considerably improved when velocity of the falling mass was imparted to the bit:

	Blow Velocity, Fps	Depth, In.	Plan Area, Sq In.	Volume, Cu In.
Bit at rest	0	0.108	1.143	0.084
Bit dropped	14	0.124	1.546	0.101

(30° wedge, kinetic energy 30 ft-lb, synthetic stone)

When the bit rested on the rock and the falling weight transferred the energy of the blow to the bit, the volume of crater produced was only 84 pct as large as that formed when the bit was attached to the falling weight and struck the rock at high velocity. The craters were similar in appearance but narrower when the bit was at rest.

Although care was taken to insure good coupling between the falling weight and the bit at rest, it is possible that loss of energy when the blow was transferred accounted for the reduced crater volume. However, since more than ten tests were conducted for each condition to eliminate such variability, it appears more likely that the decreased volume reflected the effect of the different manner of blow transfer and, to some extent, the difference in geometry of the striking mass. The coupling in the tests was probably superior to that attained in actual drilling.

Indexed Blows: Investigation of this factor was not exhaustive but aimed mainly at a study of in-

dexed blows struck on a previously cratered surface, the situation in an actual drilling process. Although several tests were run, results described here represent one typical test rather than the average of several tests, because too many different craters were involved in each test for averaging to be significant.

A succession of blows struck adjacent to one another on a fresh surface produced indexed craters four times, i.e., each crater broke into the preceding one. But on the fifth blow, breakage into the adjacent crater did not occur. Indexing was beneficial to craters 2 to 4, the volume broken being three times that of the first or last blows. Crater depths were constant.

A second row of blows, struck on the previously cratered surface, behaved unexpectedly. Each was struck midway between the axes of adjacent craters of the first row. The craters formed were similar in appearance, depth, and volume; however, they did not index together but seemed to break independently, none cratering beyond the axes of the original row. Average volume of the indexed craters was only 20 pct greater than that of crater 1 and less than half the volume of indexed craters 2 to 4.

The lack of benefit from indexed blows on a previously cratered face was apparently due to the crushed zone and subsurface fracturing produced along the axes of impact of the first row of blows. Stresses set up by a blow struck on this surface were unable to progress beyond the ruptured zone, and thus craters could not index across.

The phenomenon of indexing is also a function of bit shape, blow energy, index distance, and rock type, factors not studied here.

CONCLUSIONS

The present fundamental studies of rock penetration under impact suggest certain conclusions generally applicable to percussion drilling of soft brittle to ductile rocks.

Bit Shape: The most desirable bit shape is the wedge, because it promotes chipping in crater formation, but a wedge with an included angle greater than 90° has little merit in this regard. Particularly in soft rock, the included angle should be as small as commensurate with bit strength and resistance to wear.

Blow Energy: A high blow energy is desirable to penetrate the rock and break a large crater, since the volume of crater is approximately proportional to the energy, regardless of bit shape. But just as a threshold energy to achieve any failure exists at the low end of the scale, so an optimum energy appears to govern in the upper range of blow energies. Both undoubtedly vary with rock properties. An optimum energy exists partly because the bit length ceases to be a constant, but also because the energy is not effectively used for crater formation.

Blow Velocity: To break the maximum volume per crater, a low-velocity blow is preferable to a high one. There is probably an optimum velocity for any combination of bit shape, blow energy, and rock type.

Blow Transfer: Crater formation is aided by imparting the blow velocity to the bit, rather than by striking the blow on a bit at rest. This is a function of the geometry of the striking mass, but in general the old piston-drill principle appears to have merit, particularly when applied in a down-hole design to reduce inertia of the reciprocating mass.

Indexed Blows: Indexing is cyclical, and the critical index distance to insure 100 pct indexing with sharp wedges is almost prohibitively small. Blow energy, bit shape, and rock type all influence the critical index distance. It is even harder to insure indexing in actual drilling, since blows are struck on a previously cratered surface.

Power of Drilling Process: The linear relationship between energy of blow and volume of crater has been established. Actual drilling is concerned with advance, or volume per unit of time, and this in turn is proportional to the power, or energy multiplied by blow frequency. Thus power is even more critical than energy in a percussion drilling process. If an optimum level of blow energy does exist for penetrating a given type of rock, then faster drilling speeds can be attained only by increasing the blow frequency. This factor should be a most rewarding subject for future study.

Mechanism of Brittle Failure and Rock Penetration: In relating penetration to energy, power, and drilling speed, the most useful property is crater volume, but this is subject to the greatest deviation between runs under identical conditions. The most consistent and reproducible dimension is depth, but with all the bits studied, its behavior deviated from theory as energy was varied. Although in general the crater volume behaved as expected, it is evident that the basic assumptions for the mathematical derivation of the V-E relation are oversimplified and not entirely correct. There is still greater need for a comprehensive theory that satisfactorily explains all the puzzling aspects of percussion drilling in terms of a workable concept of dynamic brittle fracture. Improved penetration techniques depend on a solution to this problem.

The writer's experimental studies of percussion drilling fundamentals, beginning in 1954, originated with the establishment of a rock penetration laboratory at the Colorado School of Mines and are continuing at The Pennsylvania State University.

This research was made possible by a faculty grant from the Foundation of the Colorado School of Mines. The author extends his appreciation to the Foundation and to Dean Truman H. Kuhn of the school for his encouragement in the project. The Gardner-Denver Co. and the Timken Roller Bearing Co. supplied special test bits, and these and many other companies shared technical knowledge. Special commendation is due Drilling Research Inc. for having released copies of its Collected Reports to universities, making available a mass of fundamental data as guideposts to investigators in the field.

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Discussion of this article sent (2 copies) to AIME before Feb. 28, 1959, will be published in MINING ENGINEERING.

Technical Note

by SHIOU-CHUAN SUN

APPARATUS FOR TESTING COAL SEDIMENTATION

Most previous work on sedimentation of coal[1] and mineral[2,3] suspensions has been conducted in graduated 1-liter glass cylinders of 6-cm diam. With this type of large container it is often difficult to see through the suspension and tedious to perform a large number of tests. Furthermore, the heavy glass walls and the graduation lines of glass cylinders cause internal and stray reflections, respectively. To obviate these difficulties, an Atlab Emulsion Viewer from Arthur H. Thomas Co. was adopted as an alternative apparatus.

Equipment: The viewer,[4] shown in Fig. 1, consists of: 1) a stainless steel frame rack holding 21 flat-bottom Nessler tubes or an ungraduated replica 1.64 cm ID and 1.80 cm OD, 2) a movable masked 150-w lumaline lamp behind the tubes, and 3) a scaled glass panel with 100 vertical divisions in front of the tubes. The tubes are snugly held by springs in slots formed by spacer bars, which also serve as shields to eliminate stray light. The lumaline lamp is mounted behind a slit in a movable housing so that it can be positioned behind the suspension to be examined. The lowest or 100-division line on the front glass plate is leveled with the upper side of the bottom of all tubes. The scaled portion of each tube, roughly 19 cm high and 40 ml in volume, is used to study coal and mineral suspensions.

Procedure: The following procedure was used in many tests. A 1.6-gm sample of dry coal was mixed with 16 ml of distilled water in an ordinary test tube and allowed to stand for three days, with occasional shaking to insure thorough wetting of all particles. The slurry was transferred to a Nessler tube and diluted to 32 ml. The pH regulator and flocculating reagent were added, and the slurry was diluted to reach the uppermost or zero-division line. The tube was immediately stoppered and inverted downward and up again ten times during a period of 35 to 40 sec. The lumaline lamp was turned on during the inversion period. After inversion the tube was quickly returned to the viewer rack. The time elapsed for each 10-division drop of the demarcation line between solid and liquid was recorded by stopwatch until the 80-division line was reached in the zone of compression. Additional readings were taken at 15, 30, and 60 min after settling began.

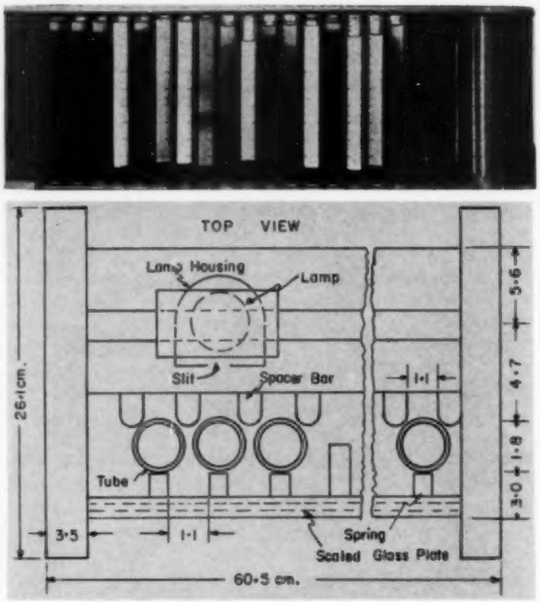

Fig. 1—The Atlab Emulsion Viewer.

The clarity of the supernatent liquid was observed also. As the settling rate became considerably slower at the 75-division line, it was convenient at this time to start the next test in a separate Nessler tube. This was continued until the suspensions in any number of the 21 tubes were tested.

An attempt was made to correlate the experimental results between the Nessler tube and a 1-liter glass cylinder. Table I shows that coal particles settle much faster in the cylinder than in the tube, which has a large wall effect.[5] The correction factor for the tube impedance is 1.662 ± 0.145 at the 40-division line in the hindered settling zone, and 1.614 ± 0.139 at the 75-division line in the compression zone. This rough correlation was established by dividing the pulp height of each container into 100 divisions and comparing the settling rates of the two containers at the same divisions. Tests were also performed to determine the accuracy of the viewer. The results, not presented, showed that error was within 10 pct.

Table 1. Effects of Containers on Settling Rate of 200/270 Mesh R & P Coal in a 4 Pct Slurry, Using 30 Mg Per Liter of Glue 2611 As Flocculant at pH 6.4

1000-Ml Glass Cylinder* (Fisher No. 8-564)			40-Ml Nessler Tube** of Atlab Viewer			
Settling Distance		Cumulative Settling Rate, Cm per Hr (Average of Two Tests)	Settling Distance		Cumulative Settling Rate, Cm per Hr (Average of Three Tests)	Settling Rate, Ratio of Cylinder to Viewer
Division	Centimeters		Division	Centimeters		
0 to 10	3.6	418±12	0 to 10	1.9	196±24	2.135±0.267
0 to 20	7.2	481±18	0 to 20	3.8	259±19	1.860±0.152
0 to 30	10.8	507±27	0 to 30	5.7	295±19	1.719±0.143
0 to 40	14.4	515±30	0 to 40	7.6	308±20	1.662±0.145
0 to 50	18.0	483±20	0 to 50	9.5	291±16	1.661±0.114
0 to 60	21.6	367±17	0 to 60	11.4	228±6	1.660±0.088
0 to 70	25.2	194±3	0 to 70	13.3	119±8	1.672±0.121
0 to 75	27.0	113±1	0 to 75	14.25	70±6	1.614±0.139

* 36-cm graduated height, 5.94-cm diam.
** 19-cm scaled height, 1.64-cm diam.

S. C. SUN, Member AIME, is Professor, Department of Mineral Preparation, The Pennsylvania State University, University Park, Pa.

TN 461 H. Manuscript, June 16, 1958. College of Mineral Industries Contribution No. 58-38. AIME Trans., Vol. 214, 1959.

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A Constituent Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers

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Please State Nature of Company's Business: ______________________

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Address where you desire Society mail to be sent (If not your business address) ______________________

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ENDORSEMENTS . . . Applications must be endorsed by three AIME Members, Associate Members, or Junior Members who know the applicant personally. Endorser should fill in the spaces to the right of his signature. (Membership in certain other technical societies that have equally high standards of membership may be used in lieu of two endorsers if necessary.)
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Please list in chronological order a complete record of your employment. Be explicit as to dates, your duties, nature of the work, and the extent to which you were in responsible charge of your own work or of the work of others. Include all positions held, whether or not they are related to the mineral industry. If additional space is needed, use separate sheet of the same size.

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I agree, if elected, to accept election, pay the necessary fees, and to abide by the Constitution and Bylaws.

Do you desire to pay the Entrance Fee in four installments of $5.00 each

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*Responsible for the conduct of technical or engineering work. Employment as a teacher may be so considered responsible for conduct of work.

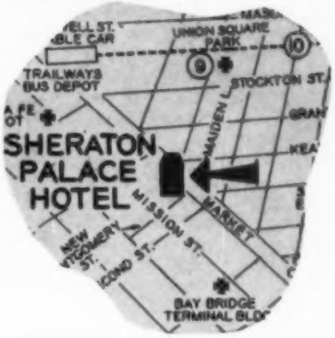
SME BULLETIN BOARD

Reports of Your Technical Society

Site of Future Center

The United Engineering Center will be built on this site facing the United Nations Plaza. Discussing current plans and contributions are, left to right, the retiring president of United Engineering Trustees Inc., W. J. Barrett; C. H. Linder, vice presiden of Engineering Services; and C. E. Davies, the executive director of the building project. To see which sections have reached their goals, read page 91.

SME's Annual Meeting ABSTRACT AND PROGRAM SECTION



California Here We Come!

Technical program and abstracts for SME's part in the AIME Annual Meeting begin on page 33. This revised program highlights social events, speakers and session chairmen, and special meetings as they were known at time of publication. All additional abstracts received after the last issue went to press are included. Later abstracts will appear in the regular abstract column next month. See you then in San Francisco!

NEWSLETTERS . . .

- Coal page 85
- Rock in the Box page 83

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Proposals For Membership

Change of Address Personals Data Boxes

These forms appear on page 100 for your convenience.

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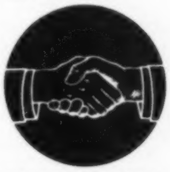
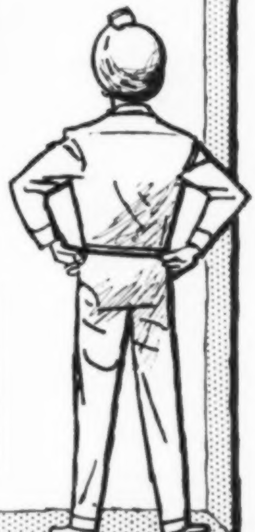


SME MEMBERS

Turn over the opposite page for start of SME's Membership Application. Help a professional colleague fill it out this month . . .



DON'T FORGET SME meetings

Board of Directors	Feb. 16	Room 2127
Nominating Committee	Feb. 17	Room 2127

Program Corrections page 80

WAAIME Summarizes Scholarship Activities

Scholarship activities of the past five years have been reported by the Woman's Auxiliary to the AIME. The WAAIME Educational Fund has given excellent support to the Institute in this field of scholarships.

Local scholarships granted by the WAAIME Sections show an impressive record. The Arizona-Tucson Section has awarded 12 scholarships for a total of $3000. The California-Northern Section granted $500 during the last five years, plus $1000 awarded last year. Colorado-Denver Section has given $3990 in scholarships, with $365 last year. Colorado-San Juan Section gave four scholarships totaling $325, with one last year for $105. The Illinois-Chicago Section has awarded one scholarship for $750. The Missouri-St. Louis Section has given four scholarships totaling $800. The New York-N. Y. Section has given a grand total of 11 scholarships of $3565 over the years, plus three last year for $900.

The Peru-Lima Section awarded nine scholarships for approximately $500 the last five years, and in the last year they have given three totaling about $250. Pennsylvania-Pittsburgh Section donated $2800 in 11 scholarships, and $1000 last year. Texas-El Paso Section gave five scholarships, that totaled $850, with three last year for $725. And finally, Utah-Salt Lake City Section gave eight scholarships over the years for a total of $2000 donated for the purpose of education.

The Cleveland Section reports that, in addition to three scholarship loans for $300, $110, and $350, they have contributed to the Cuyahoga County Nursing Home and the Inner City Parish. These excellent local projects are a sample of WAAIME's fine work.

World Power Is Theme Of Montreal Gathering

The World Power Conference, supported by AIME, ASCE, ASME, AIEE, and AIChE, held a Canadian sectional meeting in Montreal on September 7 through 11. Over 1300 participants from 50 countries discussed the theme *Economic Trends in the Production, Transportation, and Utilization of Fuel and Energy.*

The U.S. delegates took an active part in the discussion of 147 technical papers, presenting 14 papers themselves. Tours of industrial sites around Montreal added to the interest of the general conference. The St. Lawrence River power and navigation projects, the Niagara Falls power projects, and Shippingport Nuclear Power Station drew the widest enthusiasm from the participants during the field trip following the meeting.

AIME

BOARD OF DIRECTORS

Recent actions taken by the Institute Board of Directors.

► Scott Turner has been appointed by President Kinzel to be AIME's Official Delegate at the World Power Conference Sectional Meeting, Sept. 7 to 11, 1958, in Montreal.

► The Rocky Mountain Income Fund Committee has agreed to supply the Seeley W. Mudd Memorial Fund Committee with copies of the *Porphyry Coppers in 1956* at cost for free distribution to new Junior Members of AIME.

► The Metallurgical Society of AIME announced that the Institute of Metals Division Lecturer in February 1959 will be Professor Frederick Seitz, Dept. of Physics, University of Illinois.

► The Metallurgical Society announced that the IMD Lecturer for 1960 will be N. F. Mott of Cambridge University, England. In even-numbered years a foreign lecturer is invited.

► The citation in honor of the Jackling Lecturer Ralph S. Archibald has been approved as follows: "A successful career in mining geology, consulting work and operation of substantial iron ore properties, and for his lecture, 'Economic History of the Lake Superior Iron District.'"

► The suggested change in the Institute's Bylaws and Rules, as previously published in the August issue, was approved, so that hereafter the term *Entrance Fee* will replace *Admission Fee* in all instances.

► Robert M. Mahoney, AIME's representative on the EJC Air Pollution Committee, was appointed as AIME delegate at the U. S. Public Health Service Conference on Air Pollution held Nov. 18 to 20, 1958, in Washington, D.C.

► Professor H. U. Ross, Dept. of Metallurgical Engineering, University of Toronto, was the winner of the JOURNAL OF METALS Award for 1958. His paper is entitled *Smelting of Titaniferous Ores.* The award was presented in April 1958.

► The Metallurgical Society announced that the F. B. McKune Award for 1958 was presented to R. W. Joseph and L. J. Trilli for the paper *A Study of Wall Erosion in Wide Slab Molds.*

► The Metallurgical Society announced that the Open Hearth Conference Award for 1958 was presented to R. E. Stoll and E. C. Rudolphy for the paper *Effect of Nozzle Characteristics on Steel Pouring Streams.*

► The Society of Petroleum Engineers of AIME has a 30-min sound film strip on student guidance at the high school level. Preparations are being made for the other two Societies to print such a film strip if possible.

► The formation of the Golden Gate Petroleum Subsection of the San Francisco Section was approved.

► Augustus B. Kinzel announced that the Hal Williams Hardinge Award Committee has selected Dr. Oliver Bowles posthumously as the first recipient.

► Clark L. Wilson, chairman of the Saunders Gold Medal Committee, announced that the recipient of the award in 1959 will be John B. Knaebel. The citation in his honor reads: "For his versatility and courageous leadership in pioneering, exploring, developing and managing highly successful mining ventures as a leader among men—yet one of them."

► F. R. Jones, mine superintendent, MacIntyre Development, Titanium Div., National Lead Co., has been selected as the recipient of the Peele Award in February 1959 for his paper *More Rock Per Dollar from The MacIntyre Pit*, MINING ENGINEERING, April 1956.

► The following resolution was unanimously voted (at the September 19 meeting):

RESOLVED, that the Board of Directors of the American Institute of Mining, Metallurgical, and Petroleum Engineers unanimously agrees that the Utah Local Section has done an outstanding job in its arrangements for this meeting.

FURTHER, the Board wishes to express its thanks and appreciation for the successful outcome of the efforts involved.

► Establishment of the Balcones Local Section and proposed bylaws have been approved. This Section replaces the Austin-San Antonio Subsection of the Southwest Texas Section which has released the following counties: Atascosa, Bandera, Bastrop, Bexar, Blanco, Burnet, Caldwell, Comal, Dimmit, Edwards, Frie, Gillespie, Gonzales, Guadalupe, Hays, Kendall, Kerr, Kinney, LaSalle, Llano, Medina, Maverick, Mason, McMullen, Real, Travis, Uvalde, Valverde, Wilson, and Zavala. The Gulf Coast Section has released Bell, Milam, and Williamson Counties.

► Citation in honor of J. J. Mauthe, chairman, Youngstown Sheet and Tube Co., 1959 Fairless Award recipient, reads: "For his early con-

tributions to improved efficiency of blast furnace operations and masterful guidance of the steel company which he now heads."

► The following AIME representatives for ECPD have been approved: guidance, J. R. Van Pelt; student development, Curtis L. Wilson; education and accreditation, R. Schuhmann, Jr., and L. E. Shaffer; and training, J. R. Cudworth and J. J. McKetta.

► Establishment and proposed bylaws of the Hudson-Mohawk Local Section have been approved. The Section comprises the following counties in New York: Albany, Broome, Chenango, Columbia, Cortland, Delaware, Dutchess, Greene, Montgomery, Otsego, Rensselaer, Saratoga, Schenectady, Schoharie, Sullivan, Tioga, and Ulster.

► Presentation of a certificate to the outgoing chairman of the Electric Furnace Steel Committee of the Iron and Steel Div., Victor E. Zang has been approved.

► Revised bylaws of the Iron & Steel Div. have been approved by The Metallurgical Soc. board of directors and Executive Committee of AIME.

► Revised bylaws of the Extractive Metallurgy Div., The Metallurgical Society, have been approved by the board of directors of The Metallurgical Society and with incorporation of suggested changes, have been approved by the Executive Committee of AIME.

JOINT AWARDS

John Fritz Medal, 1958, to **Mervin J. Kelly,** presented at AIEE ceremonies.

Percy Nicholls Award, 1958, to **Willibald Trinks**, presented at the AIME-ASME Joint Solid Fuels Conference, October 9.

Alfred Nobel Joint Prize, 1958, to **G. Farman-Farmanian.** Presented at AIEE ceremonies.

ECPD Discusses Future Of Graduate Engineers

Engineers' Council for Professional Development held their 26th annual meeting on October 9 and 10 at the Sheraton-Jefferson Hotel in St. Louis. Committee and council meetings formed a major part of the agenda, while a ladies' program complemented the sessions and noted speakers spotlighted the program.

The luncheon speaker on Thursday, October 9, was G. A. Hawkins, dean of engineering at Purdue University. He discussed reports from the Purdue survey of Purdue engineer graduates. M. D. Hooven, ECPD president, presided, and Hon. Raymond R. Tucker, Mayor of St. Louis, welcomed the delegates.

The dinner speaker that evening was Curtis L. Wilson, dean of engineering at the Missouri School of Mines, who spoke on *Road to Survival.* Warren L. McCabe, vice president, ECPD, presided, and the president gave his report.

On Friday, the luncheon featured George E. Mowrer, director of guidance in St. Louis schools, who discussed organizing classes to provide for individual and group needs in instruction. L. G. Smith of the guidance committee opened the final luncheon.

E. Kirkendall Honored

Ernest O. Kirkendall, AIME Secretary, has been honored by a citation as Distinguished Alumnus of the College of Engineering, Wayne State University. The citation was awarded on Oct. 17, 1958, in recognition of Dr. Kirkendall's outstanding achievements and his contribution to the field of engineering. A graduate of Wayne, he received M.Sc. and D.Sc. degrees in metallurgical engineering from the University of Michigan.

Bylaws, AIME Council Of Education Approved

The Bylaws of the Council of Education of AIME have been approved as of Feb. 16, 1958, and read as follows:

Article I

Name and Object

Section 1. This unit of the American Institute of Mining, Metallurgical, and Petroleum Engineers shall be known as the Council of Education of AIME.

Section 2. The object of the Council shall be:

a. To provide a forum within AIME for the expression and exchange of ideas on education and associated problems such as engineering manpower and ethics to the extent that they are within the framework of AIME interest;
b. To provide a focal point for the exchange of ideas on matters of education between AIME and the other Founder Societies, the Engineers Council for Professional Development, or other similar organizations, and for suitable action thereon;
c. To centralize efforts of the AIME with respect to accrediting of engineering curricula;
d. To provide such coordination as may be desirable among the several committees on education of the constituent Societies of AIME;
e. To advise the Board of Directors of AIME on matters pertaining to education and to the continued healthy existence of Student Chapters from the viewpoint of educational institutions;
f. To carry on such studies, activities, and programs as are deemed proper to the interests of AIME with respect to broad educational matters.

Article II

Members

Section 1. The Council shall consist of the following members who are in good standing of the AIME and who indicate, in writing to AIME headquarters, their desire to belong to the Council.

a. All members who are engaged in active educational work in an educational institution or agency of an educational institution;
b. All members who are members of an education committee of one of the constituent Societies of AIME, as indicated by that Society;
c. All members who are representatives of AIME to ECPD or to ECPD standing Committees;
d. All members who have been selected by the respective Societies to be members of the the Executive Committee of Council.
e. All members who by occupational assignment are regularly engaged in educational or closely allied activities.

Section 2. Only members of the Council shall have voting privileges in the Council, but the forums, programs, and other meetings of the Council shall be open to participation to any member of AIME in good standing.

Article III

Officers

Section 1. The officers of the Council shall be a Chairman, a Vice Chairman, a Past-Chairman, and a Secretary-Treasurer.

Section 2. The Vice Chairman will serve in successive years as Chairman and Past-Chairman. The succession shall be automatic.

Section 3. Except as provided in **Section 2** of this article, all officers of the Council shall be elected from among its members.

Section 4. The Executive Committee of the Council shall consist of the following:

a. Chairman
b. Vice Chairman
c. Secretary-Treasurer
d. Past-Chairman

(Continued on page 80)

Council of Education

(Continued from page 79)

e. Three members at large elected by the Council from its membership.
f. Three members from each constituent Society of AIME, as selected by those Societies.

Section 5. Executive Committee members at large and those selected by the Societies shall serve three-year terms, one member from each group being designated each year to achieve rotation.

Section 6. The Chairman of the Council shall be Chairman of the Executive Committee.

Article IV

Committees

Section 1. Standing Committees shall be:

a. Meetings and Program Committee
b. Publications and Newsletter Committee
c. Accrediting Affairs Committee
d. Student Chapters Committee
e. Nominating Committee
f. Mineral Industry Education Award Committee

Section 2. Method for making appointments to standing committees shall be determined by the Executive Committee, except as provided in *Article V*, **Section 1.**

Section 3. The Executive Committee may appoint such special committees as are from time to time necessary, and shall clearly define their duties.

Article V

Nominations and Elections

Section 1. The Nominating Committee shall be appointed by the Chairman at each Annual Meeting and it shall report to the Chairman of the Council by the following May 1.

Section 2. The Nominating Committee shall designate a nominee for each of the following positions, for terms beginning at the next Annual Meeting: Vice Chairman, Secretary-Treasurer, and one Executive Committee member-at-large.

Section 3. The Chairman shall notify all members of the Council of the report of the Nominating Committee by October 1 of each year. Any ten members of the Council may submit additional nominations in writing to the Chairman. If no additional nominations are received by December 1 of each year, the Chairman shall declare the nominees of the Nominating Committee elected. If additional nominees are received, the election shall be held by letter ballot before the Annual Meeting. The nominee receiving the largest number of votes for any given office shall be declared elected by the Chairman at the annual meeting.

Section 4. Vacancies in any offices caused by death or resignation shall be filled for the unexpired term by action of the Executive Committee, except that a) if the office of Chairman becomes vacant, the Vice Chairman shall become Chairman for the unexpired term and the vacated Vice Chairmanship shall be filled by action of the Executive Committee; and b) if the office of Past-Chairman becomes vacant, it shall remain vacant to the end of the term.

Article VI

Meetings

Section 1. The Council shall meet annually at the time of the Annual Meeting of AIME. Twenty members of the Council shall constitute a quorum. The Executive Committee may meet at any time upon the call of the Chairman or by his order, provided that at least four members of the Committee are present to conduct business.

Section 2. New officers and Executive Committee members shall take office at the close of business at the Annual Meeting. The new Executive Committee shall meet at the call of the Chairman.

Article VII

Dues and Assessments

Section 1. Dues or assessments for members of the Council may be fixed by the Executive Committee, subject to approval of the Board of Directors of AIME and approval of the Council membership by an affirmative vote of the majority of those voting, either at a regularly called annual meeting or by letter ballot. No such assessment shall be valid unless notice of the proposed action shall have been published in suitable AIME publications, or announced by letter to the members, at least two months in advance of such vote.

Section 2. The Council shall conduct its budget and financial affairs in conformance with the Bylaws of AIME and Rules of the Board of Directors.

Article VIII

Contact with AIME Board

Section 1. The Chairman shall make such reports to the headquarters AIME or to the Board of Directors of AIME as are required by AIME Bylaws and Rules.

Section 2. The Executive Committee of the Council, immediately following the Annual Meeting each year, shall designate one of the Directors of the Institute Board to represent the Council and its affairs before the Board of AIME. Such contact director shall be kept advised by the Chairman of the Council of the activities of the Council. The contact director shall be invited to participate at all activities of the Council, and to offer such advice and guidance as he deems pertinent.

Article IX

Amendments

Section 1. Proposals to amend the Bylaws may be made by ten members of the Council by submitting the proposals in writing to the Executive Committee. Proposals to amend may also be made by majority vote of the Executive Committee. Proposals to amend shall be submitted by mail to members of the Council in the form of a letter ballot, and approval shall be by majority of those votes cast.

ATTENTION

Annual Meeting Registrants

Changes in room names for the sessions were not in time for the program section of the magazine, but have been made in the final program to be distributed in San Francisco. The corrections are as follows:

SME Committee of Education, Feb. 15, 2 pm: *California Room.*

Council of Education Business Meeting, Feb. 16, 9 am: *Room 2060.*

Ceramic Raw Materials, Feb. 16, 9:30 am. *English and California Rooms.*

Geochemical Techniques, Feb. 16, •9:30 am: *Room A.*

SME Board of Directors Meeting, Feb. 16, 10 am: *Room 2127.*

Chemical Raw Materials, Feb. 16, 2:30 pm: *English and California Rooms.*

Underground Mining II, Feb. 16, 2:30 pm: *Ballroom.*

Coal Symposium: Water Circuit Problems in Coal Preparation Plants, Feb. 17, 9 am: *French Parlor.*

Appraisal of Paley Report, Feb. 17, 9 am: *Rose Room.*

Health, Safety & Personnel, Feb. 17, 9 am: *Concert Room.*

Coal Division Luncheon, Feb. 17, 12 pm: *French Parlor.*

IndMD Division Luncheon, Feb. 17, 12 pm: *Rose Room.*

All Institute Session, Feb. 17, 2:30 pm: *Rose and Concert Rooms.*

AIME Annual Business Meeting, Feb. 17, 4 pm, *Rose and Concert Rooms.*

Rare and Radioactive Minerals, Feb. 18, 9 am: *Ballroom.*

Water Problems, Feb. 18, 2 pm: *English and California Rooms.*

Special Sands and Abrasives, Feb. 19, 9 am: *Concert Room.*

Cement and Aggregates, Feb. 19, 2 pm: *Concert Room.*

Oliver Bowles Is Honored By First Hal Williams Hardinge Award

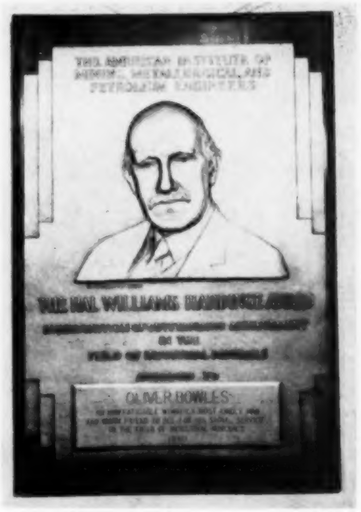
An Institute award in the industrial minerals field has been established through the generosity of Mrs. Hal Williams Hardinge in memory of her husband, the noted mining engineer and inventor. The first presentation of the award was at ceremonies of the Washington, D. C., Section on Dec. 2, 1958. It was awarded posthumously to Oliver Bowles for his achievements and service in the field of industrial minerals.

Mrs. Bowles received the placque in honor of her husband. It was particularly appropriate that the ceremonies were in Washington, where many of Mr. Bowles contributions to the Bureau of Mines were recognized by his lifelong friends. Under other circumstances the award would be presented at the AIME Annual Banquet.

The newly established award will be made from time to time upon authorization of the board of directors of AIME, acting upon the recommendations of the Hal Williams Hardinge Committee of Award. The outstanding achievement which has benefited the mineral industry may have been accomplished through writing, teaching, research, or administration, resulting in new discoveries or wider dissemination of knowledge.

Mr. Hardinge himself was the recipient of many awards honoring his contributions to the industry. He was chairman of the board of the Hardinge Co. Inc. which operates a mining and milling equipment manufacturing plant in York, Pa. His invention of the Hardinge conical mill for grinding ores earned him the AIME James Douglas Gold Medal in 1938.

Born in San Antonio, Texas, in 1885, Hal Hardinge left school at 13 to work as a printer's devil, railway newsboy, and telegraph operator, studying assaying and chemistry on the side. In 1883 he became a prospector in Leadville, Colo., and served as an engineer for many smelting and mining companies.



From 1910 to 1915 Mr. Hardinge's work as a mining engineer and consultant took him to Brazil, the Arctic, Spain, and Canada to investigate diamond mines and nickel mines, gold and silver mines for various governments. During World War I he gave his service to the Bureau of Mines in Washington.

He studied many subjects along the way, from telegraphy and stenography and special science courses at the Franklin Inst., to mining engineering at the Colorado School of Mines, where he received an honorary degree. Prospecting, assaying, and inventing interrupted his schooling from time to time.

His inventive ability soon began to assert itself so that he held over 100 patents. One of his early inventions was the Telthermoscope and fire-damp detector, to detect coal gas in mines. On his eightieth birthday he was still working on new inventions and safety devices.

His ingenuity led to the formation of the Hardinge Co. for the manufacture of grinding, classifying, and feeding devices that he had a large part in designing. The Hardinge conical pebble mill converted the preparation of ceramic raw materials from a batch to continuous process. The first closed circuit grinding mill in the cement industry was carried out in a conical ball mill and is in general use today. Autogenous grinding of nonmetallic minerals was first accomplished there by using lumps of barites to grind barites for paint and other mineral fillers. The Hardinge family has been very active in company affairs and Mr. Hardinge's son, Harlowe, is now president.

The Award named in honor of this engineer will this year honor the memory of another outstanding mineral pioneer. Oliver Bowles, born in the northern wilds of Ontario in 1887, became a prominent technologist in the U. S. Bureau of Mines, serving as special consultant long after his formal retirement. He had received the Distinguished Service Gold Medal of the Interior Department for his achievements.

Mr. Bowles' early enthusiasm was in quarrying, so he went from the University of Toronto, where he had graduated in 1907, to the University of Michigan and later University of Minnesota as an instructor. In 1914 he was appointed quarry technologist in the Bureau of Mines.

An appreciation of Oliver Bowles appeared in the November issue of *Mining Engineering*, written by his friend Oliver C. Ralston. Many warm incidents in his life were described and his interest in mining and in people was well illustrated. Mr. Ralston remarked that many visitors came to him for advice "and all left with gratitude to the person who had given self-effacing but efficient service."

The inscription on the placque is a tribute to this quality of sincere service that marked his life:

An indefatigable worker, a most kindly man and warm friend to all, for his signal service in the field of industrial minerals.

The first presentation of the Hal Williams Hardinge Award was made by Augustus B. Kinzel, AIME President, on Dec. 2, 1958. Mrs. Oliver Bowles proudly accepts the placque for her husband. At right Mrs. Bowles confers with her sons, Edgar O. and George.

Scholarships

Johnstown Coal & Coke Co.

Along with its subsidiary, the Williams River Coal Co., the Johnstown Coal & Coke Co. will again this year offer two university scholarships to students in West Virginia and Pennsylvania. The recipients may attend any accredited school of mining engineering and will be supplied with $750 a year for four years provided satisfactory work is maintained. The company will also try to find summer employment for the students, and after graduation there are no limitations on choice of employment.

Lehigh University—R. L. McCann

Lehigh University has received $10,800 to establish a scholarship endowment fund from Raymond L. McCann, president of New Jersey Zinc Co. The scholarship will be awarded to a student seeking a degree in one of the engineering departments at Lehigh, and it will continue as long as the qualifications of scholastic achievement are met and financial need continues. Mr. McCann graduated from Lehigh in 1917 and has been with New Jersey Zinc since that time.

National Science Foundation

The National Academy of Sciences-National Research Council are again assisting the National Science Foundation in its fellowship programs. Approximately 1000 graduate and 200 postdoctoral fellowships will be awarded for 1959-1960. Deadline for applications was December, and final selections will be announced on Mar. 15, 1959.

Council For Financial Aid to Education Inc.

Mining companies are playing a major role in a rising trend of financial aid to education, a recent survey indicated. Among the four mining companies surveyed, the highest total which any one gave to education was $884,750, the lowest was $5,850, and the average was $278,650. This average was exceeded only by the electrical machinery manufacturers who gave $337,300. Two mining companies each gave over $100,000 to education during 1956. The survey covered 275 major companies in 22 groups of industrial, financial, and utilities companies for the year 1956.

ROCK IN THE BOX

Mining & Exploration Division

Miners' John Knaebel Wins Saunders Medal

Those who know the prospector, Jack Knaebel, will be pleased that a man still in the full stride of his career is to be recognized by the award of the William Lawrence Saunders Gold Medal. The presentation of the AIME award will be a feature of the Annual Banquet on Feb. 19, 1959, in San Francisco.

Denver-born, John Ballantine Knaebel grew up there and in Washington, D. C.; studied three years at Cornell; took his B.S. degree in engineering at Stanford in 1929; and a year later the degree of engineer of mines. A few years later, soon after Maynard Keyes talked Franklin Roosevelt into upping the price of gold, Knaebel terminated mining-method studies for the USBM to join the many who sought Eldorado in the Philippines.

As manager of the East Mindanao Gold Mining Co., he prospected a jungle area in Surigao, mapped, trenched, sampled, assayed, drilled, sank, developed, and built a mill and a town—himself teaching native help to handle tools and work as miners.

In the early forties when everyone thought zinc had a bright future, as manager of the exploration operation of the United States Smelting Refining and Mining Co. in the Central City district, Grant County, N. M., Knaebel again mapped, trenched, drilled, sank, developed, and erected a mill to treat ore from four shafts on some 10,000 acres leased in that district.

During the last war when the Army asked U.S. Smelting quickly to reopen an arsenic mine at Gold Hill, Utah—then just an untimbered hole in the ground—Knaebel, at a time when miners were as scarce as hens' teeth, coralled a crew of Nevada bar-flies, went into production ahead of schedule, and delivered more than the estimated tonnage at precisely (true story this time!) the estimated grade, at a cost netting Uncle Sam a modest saving under the contract figure.

Knaebel then went off prospecting again on an assignment from Anaconda in Brazil and the Guianas, and had just returned when the Navajo Indian discovered uranium in the little thin Toldito limestone at Haystack Butte, near Grants, N. M. Asked to investigate, Knaebel was interested. For Anaconda he took up leases on nearly a million acres scattered across north central New Mexico, which he prospected systematically by air, ground traverse, bulldozer, and drilling—flying much of it down close to the sandstone cliffs himself. A number of small deposits, virtually in outcrops, were located in the vicinity of Grants, which a few years later led in turn to the deeper prospecting farther down dip that disclosed the Ambrosia Lake deposits.

But chiefly, 50 miles eastward of Grants, was found the Jackpile. Persistence and much pioneering in all phases of the work: the systematic radiometric surveys, drill sampling, and in analytical and milling methods and equipment, resulted in this, Anaconda's open pit mine, and the 4000-ton mill and plant at Blue Water near Grants, as yet the largest uranium operation in the country.

The William Lawrence Saunders Gold Medal, established in 1927 through a gift from Mr. Saunders, a Past-President of AIME, recognizes distinguished achievement in mining other than coal. The Medal is awarded in 1959 to Mr. Knaebel "for his versatility and courageous leadership in pioneering, exploring, developing and managing highly successful mining ventures as a leader among men—yet one of them."

Executive Committee Report

A report from H. C. Weed, acting secretary of the M&E Executive Committee, summarized the meeting held at the Fairmont Hotel, San Francisco, on Sept. 25, 1958.

The first item of business was whether to revise the bylaws to eliminate the Geochemistry Unit Committee. Mr. Hawkes reported that few were active in this Unit, and that the program, publications, and membership committees were operating with the Geophysics Unit. Mr. Weed and Mr. Simmons (Geology) were against the proposal. In a letter received after the meeting, R. J. Searls (Geophysics) was also opposed to dropping the Geochemistry Unit. The motion was made and approved that there would be no revision at this time.

Mr. Weed made the proposal that the editor of *Rock in the Box* be made a member of the Executive Committee. Since the editor would then be elected instead of appointed, the best editor, who would agree to serve, might not be chosen. This proposal was also dropped.

Finances of the Division were discussed with information from J. C. Fox. He gave a history of the Peele Award and explained proposed activities to raise enough funds to perpetuate it without the present pressure from insufficient funds. Division income cannot be used for the Award.

Mr. Fox distributed copies of the new SME membership application form and received approval of his method of contacting nonmembers whose names appear in MINING ENGINEERING news items.

The question of Membership Committee activities led to the conclusion that the best place to obtain members was at the local level. No change in the bylaws was recommended to prevent the overlap of activities within M&E, but it was

(Continued on page 92)

Editor

Address news items to: [illegible]

Education News

The School of Mines Building, University of Minnesota, is rapidly approaching completion. It will house mining adjacent to the present Chemical Engineering Department.

University of Arizona

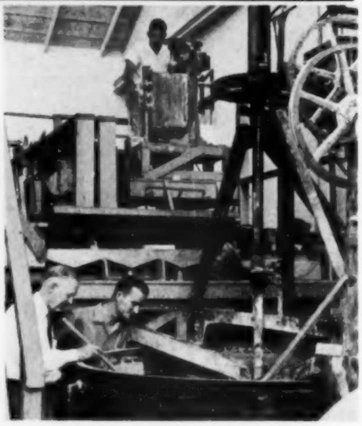
The College of Mines of the University of Arizona has acquired as a wing to the mines building a new geology building that will house laboratories, classrooms, and faculty offices. In addition, the Arizona Bureau of Mines offices and the regional offices of USGS and USBM are located in the new center of engineering education. The wing has been built by means of a state appropriation and was opened in September 1958.

• Nine seniors from the University of Arizona College of Mines participated in a tour of Kennecott Copper Corp.'s open pit mine at Ray, Ariz., in the fall. They examined the new townsite, the new smelter and mill, and facilities in Hayden. The seniors were selected as possible applicants for engineer trainee positions with the firm.

• The Arizona Bureau of Mines at the Universtiy of Arizona will establish a central repository of information concerning drilling and development of oil and water in the state. This new service is undertaken with the knowledge and interest of the USGS, the Arizona Land Office, and the Museum of Northern Arizona.

The objectives in addition to collecting samples and data, include identification of mineralogic and fossil content of samples; determination of permeability, porosity, and fluid content; and identification of rock types. J. D. Forrester, dean of the College of Mines, expects to see the repository established and able to give general service this month. As director of the Bureau, he will supervise the program. A committee to assist him includes F. W. Galbraith, W. Pye, J. F. Lance, J. W. Harshbarger, P. Johnson, G. Roseveare, and W. Peirce.

• The U.S. Geological Survey will contribute funds totaling $60,000 to the University of Arizona for geohydrology studies, part of an arid lands research program. The funds will help finance the investigation of the geologic environment in the Gila-San Simon alluvial basin in eastern Arizona. The University will match the funds from a grant of the Rockefeller Foundation. John F. Lance is project director and John W. Harshbarger represents USGS.



Daniel J. Murphy, left, professor of metallurgy at the University of Arizona College of Mines, inspects the solar furnace being constructed on the roof of the new geology building. At the right, John B. Cunningham, professor in the mining and metallurgical department, inspects the work of students in the pilot mill of the College of Mines.

Colorado Plateau Section

The AIME Colorado Plateau Section sponsored a provocative debate on the subject of engineering education and the humanities. The panel discussion was part of the September 13 meeting at Gunnison, Colo.

F. T. Davis of the Colorado School of Mines Research Foundation led the discussion and noted that many of the engineering schools are often too technical and are "ill-equipped to teach their students subjects in human thoughts and relations . . ."

Yet the engineer today must know how to cope with human relations and must be proficient in the use of English. Furthermore, labor union negotiations require the ability to reason and persuade, to analyze and debate.

Other panel members were H. McNeil, Stearns-Roger Mfg. Co.; L. J. Parkinson, Colorado School of Mines; C. G. Warren, Western State College; and M. Bowen, Golden Cycle Corp. They debated the responsibility of the engineer toward society, but felt that many do not take time to speculate about the effect of their work on the welfare of the world. One belief was expressed that the public should not expect engineers to

(Continued on page 86)

At the beginning of the year it is appropriate that the accomplishments of the first year of *Coal News* be reviewed. The May issue began with a report of the scholarship committee which has helped 18 students over the past years. Several issues of *News* plugged the membership drive and emphasized the role of each engineer in welcoming new members.

Reports of coal meetings are a regular feature of the column, and the Central Appalachian Section-Coal meeting in Lexington received advance notice and coverage, along with plans for the Annual Meeting, to keep members abreast of coal affairs.

Division officers were introduced with brief biographies and new nominations were reviewed. One special program that has drawn interest from the Division was the Pilot Student Venture in cooperation with WAAIME. Young engineers of tomorrow were given a chance to see mining in action with encouragement from leaders in the field.

A closer review of committee activities includes the reports of various chairmen. Charles E. Lawall of the scholarship selection committee sent in the following resume:

> The Coal Division has always taken a very great interest in assisting worthy college students who are training for work in the industry. This program is implemented by two committees of the Division: namely, the scholarship fund committee and the scholarship selection committee. The fund committee, directed by Hugo Nyquist, chairman, has the responsibility of obtaining the student aid funds.
>
> Selecting the recipients of the scholarship awards and following their progress in their college work is the duty of the scholarship selection committee.
>
> The committee has been very fortunate in having as its co-chairman M. D. Cooper. He has for many years been director of mining education of the National Coal Assn. and in that work he has visited all of the universities in this country offering courses in mining. In his visitation work, he has been able to visit the various students with scholarships at mining schools and in this way follow their progress.
>
> The committee not only follows the work of the student in his college program, but on completion of his work is interested in assisting him, as far as possible, in locating suitable employment in the coal industry. It has been a great satisfaction to members of the committee to see how recipients of the scholarship awards have progressed after completing their college work.
>
> There is a close liaison between the professors of mining engineering of the various universities and the committee. Four of the members of the committee, namely Edward A. Dines, Robert T. Gallagher, G. Ralph Spindler, and Ernest M. Spokes, are heads of the mining departments in their respective colleges. These professors not only bring to the attention of the committee worthy students who need some financial assistance, but are quite helpful in the administration of the program at their universities.
>
> At the present time there are four students studying mining engineering and receiving aid. The scholarships, which are usually given over a four-year period, providing satisfactory records are maintained by the recipients, are divided as follows—$350 a year for freshmen, $400 a year for sophomores, and $450 a year for juniors and seniors.

In addition to scholarships, the Division participates in presentation of honors such as the Percy Nicholls Award. The committee chairman for this award is Elmer R. Kaiser, whose report reads as follows:

> The Percy Nicholls Award for 1958 was presented to Professor Emeritus Willibald Trinks of Pittsburgh at the dinner meeting of the AIME-ASME Joint Solid Fuels Conference in Old Point Comfort, Va., Oct. 9, 1958. The presentation was made by E. R. Kaiser, 1958 chairman of the committee.
>
> The award is given annually in behalf of the Fuels Division of ASME and the Coal Division of AIME. The recipient is selected by the committee for "Notable scientific or industrial achievement in the field of solid fuels." Professor Trinks has been regarded for many years as the outstanding authority on fuels, combustion, and furnaces in the steel industry. For 38 years he was head of the mechanical engineering department of Carnegie Inst. of Technology, Pittsburgh, and is now a consultant.

The membership committee personnel have been working diligently to obtain new members for the Coal Division. The latest reports from headquarters showed that there have been 72 new members added, 58 losses in membership, for a net gain of 14.

Many prospective members have been given applications and it is hoped that the original estimate made earlier in the year will be met. The cooperation of the entire membership of the Division is appreciated, for many new members have been introduced to AIME through co-workers in the industry who realize and advertise the advantages of membership. The drive to build membership before the February meeting can be further helped by individual interest, by personal appeal.

The important area of meetings and arrangements is covered by the field meeting planning committee. During 1958 two meetings were held and many more planned. The Lexington, Ky., meeting on June 13 and 14 was held jointly with the Central Appalachian Section, as already mentioned; AIME-ASME Joint Solid Fuels Conference was sponsored by the Fuels Division, ASME, as well as the Coal Division. Plans for the Annual Meeting have been carefully reported as they grew (see page 33).

A meeting in Waynesburg, Pa., has been tentatively planned for June 15, 1959. The Pittsburgh Section will be host. A joint meeting with the SME Industrial Minerals Division has been planned for next September. It will be held at Bedford Springs, Pa. In October another Fuels Conference, this time in joint sponsorship with the Utilization and Preparation Division of ASME, has been scheduled for Cincinnati.

There has also been some discussion concerning the possibility of a Coal Division meeting in Illinois in 1960 with a Mid-West section as host.

The chairmen who have provided the information for these two reports are C. M. Donahue of the membership committee and Edward G. Fox of the field meeting planning committee.

In February *Coal News* will contain resumes of the activities of the commodity and technical committees.

Education News

(Continued from page 84)

worry about the effects of their actions—there just isn't time.

To balance the statements on the humanities were the views that present technical courses are necessary. "Engineering reaches a point of complexity where it is not possible to add courses to the line of study. Engineering schools just don't have time to devote to the humanities," one speaker declared.

Several possible solutions were offered. One involved summer study in the humanities. Another speaker tossed the problem back to the secondary schools.

There are many engineers well versed in the humanities, it was emphasized. Again, the question was turned back to grade and high school preparation; the early years are the time for solid training in English plus incentives for a variety of cultural interests. This led to a discussion of inadequate teaching, lack of guidance toward future careers, and low pay for teachers. The parents, too, must share the responsibility of educating their children to have wide interests and a thirst for knowledge.

A panelist had a partial answer to the question of time: "Many people feel that once a person leaves school he quits learning. But I think engineers have ample opportunity to learn the humanities—and other subjects—after graduation."

New Mexico Inst. of Mining & Technology

The New Mexico Inst. of Mining and Technology has appointed 17 new staff members, mainly in the research and development division, representing 10 states plus Iraq and Japan.

Nobuichioro Kitagawa has been employed in the research and development division as a research assistant and Mahdi Hantush of Baghdad will serve as senior hydrologist and professor of hydrology. Other appointments include: *S. J. Crosby*, junior physicist; *H. L. Giclas, Jr.*, junior mechanical engineer; *J. P. McLain*, mechanical engineer; *J. H. Aloway*, machinist; *K. Hollingsworth*, machinist; *J. Deatherage*, assistant field engineer; and *E. T. Nesdill*, assistant mechanical engineer.

Additions to the college division include *E. C. Coolidge*, chemistry; *B. Wood*, professor of chemistry who is returning from Zurich; *W. Latvala*, associate professor of mining; and *H. P. Wells*, head of the physical education department.

Two new members of the Bureau of Mines staff at the University are *C. F. Austin* and *W. Bertholf*. The final two new staff members are *A. Holmes* and *J. M. Martinez*.

First in line for registration at left are S. L. Chabot, Jr., and W. Dowdey as the conference began on Friday morning at the hotel.

Southeast Section Gathers in Georgia

The Southeast Section fall meeting was held at the Dinkler Plaza Hotel in Atlanta, Ga., on Oct. 14 and 15, 1958. Nelson Severinghaus, Jr., was general chairman, and program arrangements were handled by J. A. Hagy and A. D. Annand. Mrs. Severinghaus, Jr., was in charge of the special features for the women, with tea at Rich's Department Store.

The Friday morning session began with a paper by H. W. Straley, III, and J. E. Husted, entitled *Mineral Engineering and Mineral Economics in Industrial Developments and Area Planning Programs.* A. O. White also spoke, and The Georgia Marble Co. presented the film *Producing America's Buried Treasure.*

In the afternoon three papers were presented. *Pneumatic Conveying—Air Moves Dried Pulverized Materials for Industry* was given by W. F. Hahn. Owen Kingman gave the second paper, and J. C. Blair closed the session with a discussion of copper metallurgy.

That evening a social hour preceded the banquet of ham steak and red snapper, and dancing rounded out the evening entertainment.

On Saturday the field trip occupied the morning and the afternoon featured the football game—Alabama vs Georgia Tech. The ladies program included shopping, tea, and bridge in their own headquarters of the hotel.

The Owens-Illinois Glass Plant, highlight of the field trip, is only a year old, and is widely acclaimed for its materials handling system for raw materials and finished products. The tour provided an educational session to close the conference.

Speakers and field trips, including a football game, filled the program and provided these interesting shots. At left, the morning session presented A. O. White, Jr., consulting engineer, who spoke on "Preplanning for Reducing Costs." Beside him is the chairman, J. A. Hagy, who was also program chairman. In the corner below is Owen Kingman, chief geologist for Tennessee Copper Co., who addressed the afternoon session on "Geophysical and Geological Methods of Exploration of Ore in the Ducktown Basin." Both of these sessions were held in the Rainbow Roof. The field trip photo below was snapped on the way to the Owens-Illinois Glass Plant. Harold Ottesen, plant manager, guided the members to the two largest glass container furnaces in the world housed in this up-to-date plant.

Around the Sections

• The **Upper Mississippi Valley Section** held a fall meeting on Oct. 1, 1958, at the Wisconsin Inst. of Technology in Platteville, Wis. Lee Holt, regional director of the Ground Water Branch, USGS, was the speaker. A number of students were section guests.

• The **Knoxville Area Subsection,** Southeast Section, sponsored two illustrated talks on October 17 at the Holston Hills Country Club. Wilbur T. Stuart and W. O. Harmes were the lecturers.

• The regular business meeting of the **Mexico Section** in October featured Javier Sáuza G. from Harbison Walker Flir S. A., who spoke on refractory bricks, manufactured in Mexico.

• A recent report on 1958 activities has been received from the **Mining Branch, Southern California Section.** On February 13 at the Engineers Club in Los Angeles, Russell W. Mumford spoke on *Salines in Europe: 1957.*

On March 20, a student participation meeting was held, with Richard O. Stone discussing *The Geology and Economic Significance of Playa Lakes.*

• The **Bisbee-Douglas Subsection,** Arizona Section, met on September 23 in Bisbee to hear Ray Poulsen of Peter Kiewit Sons Co. discuss *Driving The Mule Pass Tunnel.*

• The **Ajo Subsection,** Arizona Section, held a business meeting and dinner on October 9. After dinner Robert E. West, Stanley Jones, and James E. Briggs reported their impressions of the American Mining Congress meeting in San Francisco. Then T. R. Herndon showed two films on Mexico.

• The **Lima, Peru, Section** welcomed E. P. Caldwell, technical representative of Cyanamid International, at the September 17 luncheon meeting. Mr. Caldwell spoke on *Classification of Mineral Combinations.*

The October meeting was honored by Juan E. Elguera, Peruvian Government representative to the United Nations convention on nonferrous metals in London, who reviewed the findings of the conference.

• **Southwestern New Mexico Section** held a technical session in the Bayard Lions Club on August 21. Two films on atomic energy were presented by Professor Brandenbosch which had been furnished by Pacific Gas and Electric Co.

• The October meeting of the **El Paso Section** featured a movie on *Power From Uranium* at the Hotel Cortez. Allis-Chalmers Mfg. Co. provided the film and J. E. Douglas presided.

• A dinner meeting complete with floor show highlighted October events for the **Pennsylvania-Anthracite Section.** Principal speaker at the technical session was J. E. Ippoliti, who presented an illustrated address on *Accuray and Its Application to Production of Quality Coal.* J. T. Griffiths outlined the building fund campaign for the United Engineering Center. The meeting was held at the Mayfair Supper Club in Wilkes-Barre, Pa.

• The **Lehigh Valley Section** presented John S. Nielsen, chairman of the Dept. of Metallurgical Engineering at New York University, for a discussion of Soviet metallurgy. The executive committee meeting and dinner were held at the Hotel Traylor in Allentown, Pa., Oct. 24, 1958.

• The September gathering of the **New York Section** enjoyed a double feature talk on nonferrous metals at the Mining Club. Speakers Irving Sipkowitz, assistant to the president, Reynolds Metals Co., and Simon Strauss, vice president, American Smelting & Refining Co., both voiced optimism—with reservations—over the future of aluminum, copper, lead, and zinc.

The October meeting featured an address by Bruce Old, vice president of Arthur D. Little Inc., on *Direct Reduction of Iron Ore.*

• The **Coeur d'Alene Subsection,** Columbia Section, October 24 meeting in Kellogg, Idaho, presented a movie by Atlas Powder Co. on *The Big Blast* at Promontory Point, Utah, and a review of a trip to Australia by A. Y. Bethune, manager of metallurgy for Bunker Hill Co.

• Members of the **Pittsburgh Section** were treated to a program on Russian iron and steel industry at a dinner sponsored by the **Mineral Industry Group** on October 8. A panel discussion included J. B. Austin, N. B. Melcher, and G. Mohling who had recently toured Russia.

• The **Smelting Division** of the **Arizona Section** toured the International Smelting and Refining Co. plant in Miami, Ariz., on May 3 and were entertained at lunch by their hosts at the Cobre Valley Country Club. After lunch, James E. Foard, smelter superintendent, Morenci Branch of Phelps Dodge Corp., presented a paper on continuous and intermittent smelter operation. A second paper on the design of reverberatory gas burners was given by Warren W. Whitton, metallurgist, El Paso Smelting Works, Asarco, before cocktails and dinner.

• The annual spring meeting of the **Underground Mining Div., Arizona Section,** was held at Cananea, Sonora, Mexico, from June 13 to 15. The Cananea Consolidated Copper Co. served as host at the opening dinner Friday evening at the country club. A. J. Fenn, chairman of the division, introduced the speakers—R. F. Torrance, A. Sevilla, and W. A. Humphrey—who discussed the history and geology of Cananea, followed by a discussion of mining methods. On Saturday morning the visitors inspected the east area underground mine before lunch, and

there were optional trips afterwards to various parts of the plant. A picnic by the swimming pool completed the conference.

• Fall activities of the **Montana Section** started on September 27 in Columbia Falls. The Anaconda Aluminum Co. hosted an excellent dinner while the ladies dined at the Big Mountain Chalet in Whitefish. Lee Holscher, engineer for Kaiser Aluminum Co., gave an address on *The Fabrication of Aluminum*. On Sunday the group inspected the Anaconda aluminum plant.

• The **Uranium Section** resumed regular meetings September 9 with a program on investment methods sponsored by Merrill, Lynch, Pierce, Fenner, and Smith. The meeting at the M-4 Ranch included a movie.

The October 7 meeting highlighted a talk on *Mining Law Policy* by Robert Terrell of the U.S. Forest Service.

• The **Minnesota Beneficiation Subsection,** Minnesota Section, met on September 27 to tour Reserve Mining Co.'s taconite concentrator at Silver Bay, Minn. Cocktails courtesy of Reserve and dinner were followed by a movie on the Reserve project and talk by R. J. Linney.

• The **Niagara Frontier Section** met on October 1 to hear L. M. Pidgeon, head of the Dept. of Metallurgical Engineering at the University of Toronto. The nominating committee for 1959-1960 are: D. C. Hilty, G. B. Michie, D. L. Clark, E. A. Gietzen, C. W. Hart, G. L. Cox, and M. S. Burton.

• At the **Reno Subsection,** Nevada Section, meeting, September 19, Robert C. Horton described the cutback in mineral production in the state, indicating that protection from foreign imports was necessary. George W. Malone, Nevada Senator, was also introduced at the meeting.

• The **El Paso Section** meeting, September 10, was held in the ballroom of the Hotel Cortez, where Joseph R. Smiley, president of Texas Western College, spoke on recent trends in engineering education.

• The **Wyoming Mining and Metals Section** met on August 23 in Riverton. A field trip starting at Jeffrey City led to luncheon at Luck MC. Wortham Machinery Co. gave a cocktail party before dinner at the Legion Hall. Hank Wardwell summarized the organization of AIME in an after-dinner speech. New Section appointments include Henry G. Fisk as Section Delegate and Albert V. Quine as alternate.

• The **Eastern North Carolina Subsection,** Southeast Section, met at Chapel Hill on October 4 for a social hour and dinner. John D. Morgan gave an address on *National Mineral Policies in the Nuclear Age—The U.S. and the USSR*. Dr. Morgan is an internationally known mining consultant who has served in many governmental positions.

• The **Mexico Section** on September 8 heard Ralph Balent speak on *Atomic Reactors and Principles of Atomic Engineering*. A movie was included in the program.

• The **San Francisco Section** cancelled its September meeting but extended a welcome to the newly organized Golden Gate Petroleum Subsection.

• The **St. Louis Section** heard Glen M. Hanson, Allis-Chalmers Manufacturing Co., discuss the history of the grate-kiln system for pyroprocessing iron ore, on September 12. Officers for 1959 are: chairman, Gill Montgomery; vice chairman, Gordon M. Bell; and secretary-treasurer, Norman S. Geist.

• The **Lima, Peru Section** sponsored a *Montana School of Mines Day* on August 20. John W. Howard spoke on *The Background of the U.S. Foreign Aid and Mutual Security Program*. He had been connected with the program in Asia and Europe before coming to Peru.

• Norwood B. Melcher reported on his recent trip to Russia at the **Washington, D. C., Section** dinner meeting on October 7. Mr. Melcher is chief of the Pyrometallurgical Laboratory, USBM, Pittsburgh, and spent 30 days in Russia with a group of American iron and steel specialists.

The Woman's Auxiliary gala fall get-together took place on October 3 at the Congressional Country Club, with husbands and friends invited. Mr. and Mrs. J. Howard Heginbotham showed slides of the Middle East for the evening entertainment.

• The **Southeast Section** met on September 24 in Birmingham under the chairmanship of Robert Blair. Louis Zager, Helmick Co. Assoc., Cleveland, gave a talk on *Operation Analysis and Cost Control for the Mining Industry*.

• The **Chicago Section** meeting on October 1 featured an address by Denis J. Carney on *Steel Making in Soviet Russia*. Mr. Carney is division superintendent of steel production, U.S. Steel Corp., Duquesne Works.

• The **Lehigh Valley Section** fall field trip toured the U.S. Army Nike Site near Norristown, Pa., on September 27. M. S. Childs was the presiding officer.

• The **Boston Section** met at the Faculty Club of Massachusetts Inst. Technology on October 6 to hear Warren K. Lewis, MIT professor, discuss *The Engineer—Key to Progress*. The general meeting subject was the contribution of engineers to society.

• The **Morenci Subsection,** Arizona Section, met on September 17 at Longfellow Inn. Program was American Cyanamid's film, *The Man in the Doorway*.

Varied Program Sparks Debate on Science And Education in Gunnison

The AIME Colorado Plateau Section held a comprehensive program on September 13, including a field trip to the Gunnison mine and mill, and an up-to-date technical session that sparked discussion.

Saturday morning, September 13, a large group toured the mill and the Los Oches mine before gathering at the Elks Club for the afternoon session. Robert Ward of Standard Uranium Corp. discussed the mining and milling problems of the Crested Butte area site of company operations.

Warren Wagner, consulting geologist of the E. I. du Pont de Nemours and Co., presented a paper on the columbite deposits of the Powder Horn area. He told the group that 20 million tons of columbite ore exist in the area, but stated that there is not enough information at present to prove the economy of removing the ore. Existing reserves could last 300 to 400 years at the present rate of consumption, but Dr. Wagner sees future use for the metal that would increase production and lower the exorbitant costs.

Another interesting highlight of the meeting was a panel discussion of *Humanities in Engineering Education*. F. T. Davis moderated the discussion with questions directed at H. McNeil, L. J. Parkinson, C. G. Warren, and M. Bowen. Inadequate training in the humanities was the major criticism of engineering programs. More than 95 pct of courses offered at engineering schools are highly technical and scientific. But the engineer must cope with issues outside his specialized field, such as labor union negotiations, personnel problems, and consideration of the effect his work will have on society.

The panelists pointed out, however, the importance of maintaining the basic technical studies. They discussed prior preparation in grade and high school and the inadequacy of career guidance for students. Many provocative questions were raised during the session. The issues themselves are discussed further in *Education News*, p. 84.

After the debate, S. Power Warren led a discussion of AIME technical programming. In the evening there was a dinner-dance at the Elks Club, preceded by a cocktail party.

Upper Peninsula Section Holds All-Day Fall Meeting.

On Saturday, September 27, the Upper Peninsula Section held a fall meeting in Iron Mountain, Mich., with about 150 in attendance. Historical preservation of important mining sites is a major concern of this Section and tours of famous mines highlight the programs. The Quincy Hoist project has been one of the recent endeavors to promote the preservation of Michigan's iron range and copper country sites.

The meeting began at the Pine Grove Country Club for breakfast and registration. A tour of the Hanna Co.'s Groveland mine filled the morning with interesting facts about open pit mining. Floyd Lee, superintendent; E. W. Geist, manager; and Paul Zimmer, geologist; described the operations to the group.

A buffet luncheon and short business meeting for Section members and the Ladies' Auxiliary followed. John C. Wangaard was elected chairman, K. Spiroff became vice chairman, and Roy W. Drier continues as secretary-treasurer. The Ladies' Auxiliary elected Mrs. M. E. Volin as president. The new Section delegate will be Wayne Seppanen with D. Kelly Campbell as alternate.

An afternoon tour included the Kingsford plant and recently opened Iron Mountain Iron Mine, a tourist attraction developed from the old Penn Mine. The members expressed their interest and surprise in discovering what this new area had to offer. A glimpse into the past showed the operations begun in 1877 and continued until 1945. James Goulette and associates were hosts at the mine and the Kingsford Co. at the plant.

Other sights of interest in the area, but not included on the tour, are the Cornish Pump, put into service in 1893, and the Devils Ice Box, a sheltered exposure where iron ore was discovered in 1871. This beautiful site is a great attraction for geologists.

A smorgasbord dinner and dancing in the evening wound up the program. Cocktails before dinner were courtesy of Brebner Machinery Co., Champion Inc., Charter Inc., Clairmont Transfer, Lake Shore Inc., and W. B. Thompson Co.

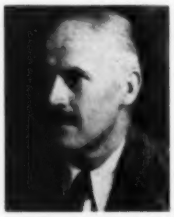
Officers of the AIME Upper Peninsula Section are John C. Wangaard, new chairman; Victor E. Kral, retiring chairman; Mrs. M. E. Volin, new Ladies' Auxiliary president; Kiril Spiroff, vice chairman; Mrs. Carlton Bailey, retiring WAAIME president; and Roy Drier, secretary-treasurer. The all-day fall meeting was held on September 27.

International Exchange For Broader Mining Education

A Distinguished Visiting Lecturer at the University of Minnesota in the spring will be Sir Harold Jeffreys of Cambridge University. He will present a series of lectures on *Elasticity and its Geophysical Applications*, with special reference to recent work in related fields such as rock flow. Mr. Jeffreys is renowned for his books on geology and physics.

A distinguished professor from the University of Minnesota, Harold M. Mooney, will, at the same time, be visiting lecturer at the Institut für Geophysik, Eidg. Technische Hochshule, in Zurich, Switzerland. Professor Mooney will be sponsored by a grant from the American-Swiss Foundation for Scientific Exchange. He is an associate professor of geophysics at Minnesota.

Six visiting lecturers in mining have been appointed at the University of Guanajuato, Mexico. The lectures have been scheduled under the auspices of the University's School of Mines. The men participating in this program of technical exchange are: F. C. Green, general manager of Utah Copper Co., Salt Lake City; C. D. Michaelson, mining operations general manager for Kennecott Copper Co.; George Ordonez, manager of



H. JEFFREYS

H. M. MOONEY

Kenmex Co., Mexico City, Mexico; A. W. Ruff, assistant underground superintendent for Cananea Consolidated Copper Co., Mexico; and Ing. Oscar Sanchez D., chief of milling operations for the American Metals-Climax Co., Mexican Div.

Post Annual Meeting

Univ. of Arizona Symposium and Educational Course on the Fluidizing Reactor

EDUCATIONAL PROGRAM—Monday, February 23, 1959 through Friday, February 27, eight hours per day. Registration Room 102, College of Mines, 8:15 a.m.

Designed for engineers who will have control or be directly or indirectly connected with the operation of a fluidizing reactor.

The fee for the educational program will be $30.

SYMPOSIUM on the "Application of the Fluidizing Reactor to the Mineral Industry"—Monday, March 2, 1959 and a field trip on Tuesday, March 3, 1959 to the new smelter at Hayden, Arizona, owned by Kennecott Copper Corporation. Fee $10.

Contact: Prof. Sigmund I. Smith, College of Mines, U. of Arizona, Tucson. (Earlier details MINING ENGINEERING, December, p. 1279.)

Continuation-Progress of Building Fund

The Utah Section was the first to reach its goal in securing contributions to the United Engineering Center Building Fund. As this is being written, on Dec. 16, records at AIME headquarters show that 100 Utah Section members had pledged $8,955, which is 109 pct of the Section's goal. Many members of the Section remain to be approached. The excellent results stem from the organization of the campaign directed by Norman Weiss and reflect the enthusiasm of his cohorts.

Two Petroleum Sections to exceed their goal are the Gulf Coast Petroleum Section which has secured $25,190 from 785 members and the New York Petroleum Section with $8,165 from 30 members.

The Tri-State Section, with only 76 members, reached its goal early in December.

Other Sections are active and telegraphic reports indicate that the Pennsylvania-Anthracite, Uranium, and Montana Sections have attained their targets; St. Louis, Ohio Valley, and Colorado Plateau are well on their way.

In spite of these excellent reports, AIME as a whole, with 34 pct of its goal of $500,000 attained at mid-December, was lagging behind all the other societies in percentage of goal attained, with the exception of ASCE. Many AIME members had not yet been approached but everybody will have a chance to help build the new home of the engineering profession before the campaign closes.

United Engineering Trustees have announced that, as of December 16th, 274 pledged contributions from industry total $3,818,708 toward the United Engineering Center Building Fund.

In addition to the results obtained by Louis S. Cates and H. DeWitt Smith in the nonferrous metal industry, Leo F. Reinartz in the ferrous industry has helped raise pledges of approximately half a million dollars.

ENGINEER*

"EJC's Report on What's Happening in Engineering"

*A Periodic Newsletter from Engineers Joint Council • 29 W. 39th Street, New York 18, N.Y.

EJC Insignia

The new insignia, chosen by a poll of the Board of Directors, from a large number of designs that were suggested, is used for the first time on the masthead of the newsletter and shown here. This may be used in many ways in the future to identify materials from EJC and a modification of the design will be used as the EJC corporate seal.

Well Deserved Award

In an unprecedented action, the EJC Board, at their September meeting, presented Harold S. Osborne, chairman of the Constitution and By-Laws Committee, with an illuminated scroll in recognition of his excellent work and long devotion to the cause of unity in the engineering profession via EJC.

1958 Surveys—Professional Income of Engineers

The most comprehensive study of engineering salaries ever made in the U. S. has been completed by EJC. The final report, published at the end of 1958, is substantially expanded over the 1956 survey, with over 650 participating organizations. It contains data broken down into some 20 industrial activities, various levels of government, and engineering education. Special tables present separate data for engineers with master and doctorate degrees. Advance orders for prompt mailing should be addressed to EJC— 29 W. 39th St., New York 18; price, $3.00 a copy.

Demand For Engineers

EJC's annual study on *Demand for Engineers* has been completed. The published report appraises current industrial and governmental needs for engineers and contains other significant data on engineering employment from organizations employing over 200,000 engineers.

New EJC Member

Acceptance of the South Carolina Society of Engineers as an affiliate member of EJC was voted by the Board in September. This brings EJC's membership to a round 20.

EJC-ECPD

The establishment of a joint committee, charged with the development of a plan for closer affiliation of EJC and ECPD, was voted at the September meeting of the Board of Directors. This Committee will consider several functional plans for an amalgamation and will consolidate recent discussions of the problem toward a plan of action.

National Defense Education Act of 1958

Title VIII of this act provides $60,000,000 for vocational education programs. In effect, it opens the door for vocational education in the various states to train engineering technicians. EJC feels that this has serious and far-reaching implications for the *engineering team* concept and for all it involves. Title IX: Another part of the bill of great interest to engineers directs the National Science Foundation to establish a *Science Information Service* for abstracting and translation. Title IX includes the fact that EJC has already expressed interest and offered assistance in the construction of the Science Information Council, the advisory group to the proposed Science Information Service.

Personnel

(Continued from page 2)

edge of machinery, both mechanical and electrical. Salary, $10,000 to $11,000 a year. Location, Far East. F6734.

Mechanical-Electrical Supervisory Engineer, to oversee power plants, electrical installations, shops and machinery of established mining and milling company. Must have knowledge of steam turbine power plants. Good living conditions. Salary, open. Location, Mexico. F6606.

Export Sales Manager, with engineering training and at least ten years foreign sales and office experience, particularly in Latin America, covering well drilling equipment and supplies. Salary, open. Some foreign traveling. Headquarters, Midwest. W6553.

Mining Engineer, young, with mill experience, for open pit manganese project. Salary, open. Location, Virginia. W6531.

General Superintendent, expert in the processing of bentonite, particularly conversion of calcium bentonite into sodium bentonite. Salary, open. Location, Greece. F6340.

District Sales Representative, for manufacturer of heavy construction and mining equipment. Must be experienced in application of excavating loading equipment. Sales experience desirable. Headquarters, New York. W6179.

Chief Estimator, mining, metallurgical engineer, B.S., for mining company. Must have at least ten years experience in construction and mining work; knowledge of estimating, mining and metallurgical plants. Will supervise small group and handle project study in estimating, as well as estimating for plant design. Salary, to $12,000. Western U. S. S3916-R.

Mining Engineer, B.S. in mining engineering, for field exploration of rock deposits, core drilling and analysis, and quarry development. Must have eight to ten years experience and knowledge of geology. A car will be required for 50 pct traveling on field trips and rock exploration work. Salary, $7200 to $7800. The employer will negotiate placement fee. Location, north Chicago. C7113.

Geophysicists. a) *Geophysicist or Physicist,* for theoretical research in all phases of mining geophysics. b) *Geophysicist,* with some electronic capability for electrical field exploration and interpretation. Salaries, open. Headquarters, Connecticut. W6788.

Rock in the Box

(Continued from page 83)

suggested that the Division contact Local Sections for persons to represent M&E Units in the sections. Next year this might be done by the Division Membership Committee chairman, with the help of the Unit Membership chairmen.

Mr. Fox and C. L. Wilson, who had attended the SME Board meeting in Salt Lake City, reported that the clarification of the M&E bylaws regarding the nominating committee had been approved. The consensus of opinion was that no further changes in bylaws should be sought until a few years experience have allowed a test period for the new bylaws.

February Agenda

Agenda for the February meeting has been proposed as follows:

- Call to order by Chairman
- Check for quorum
- Secretary and Treasurer's reports
- Report by each Unit Committee Chairman
- Open suggestions from floor and business arising from the reports
- Consideration of fund raising for Peele Award
- Introduction of new officers

Personals

D. J. DRINKWATER

W. P. YANT

In the recent consolidation of the Colorado Iron Works with its parent company, The Mine and Smelter Supply Co., **Donald J. Drinkwater** became manager of the new Manufacturing Div. of the latter company. He had formerly been assistant manager in the Marcy Mill Div.

William P. Yant was awarded the Arthur Williams Medal for "outstanding contribution to the conservation of human life." Dr. Yant is director of research and development for Mine Safety Appliances Co. He received the award at the annual dinner of the American Museum of Safety in New York. Dr. Yant's entire professional career has been devoted to the improvement of health and safety.

R. E. Hamilton, formerly mine manager for Copper Rand Chibougamau Mines Ltd., is now mine manager for Bethlehem Copper Corp. Ltd. in Ashcroft, B. C., Canada. A new underground sampling program has been outlined and is under way. The consulting engineer on the project is **B. S. W. Buffam.**

Robert Schoen, geological engineer for the U. S. Atomic Energy Commission, started work for a Ph.D. in geology at Harvard University this fall.

Peyton R. Coffman, who was a junior geologist for Kaiser Aluminum and Chemical Corp. presently is serving as a troop-carrier pilot at Pope Air Force Base in North Carolina and hopes to combine flying with geology when he has completed his Air Force tour of duty.

Seymour Merrin is studying at Pennsylvania State University. He had been a geologist for the USGS Quality of Water Branch, in Columbus, Ohio.

L. D. Barry, who had been superintendent, Ike Shaft, for Hidden Splendor Mining Co. in LaSal, Utah, now is mine superintendent at Four Corners Exploration Co., Grants, N. M.

Dietrich H. Rontz has become an agent for Le Roi Div. of Westinghouse Air Brake Co., Butte, Mont. He had been a salesman for the Denver Air Machinery Co.

J. K. Whatmough, general manager of North Rankin Nickel Mines Ltd., has become mining engineer for the Ontario Securities Commission, a newly created post to facilitate filing of mining companies with the commission. Formerly the work was done by prominent consultants.

Bernard B. Abrams assumed command of the Rossford Ordnance Depot, arriving here from Japan where he served as commanding officer of the U. S. Army Logistical Depot at Camp Tokoroza. Col. Abrams also served in Washington as deputy chief and executive officer of the army division of the National Guard Bureau.

Richard F. Pascoe, geologist for the Phillips Petroleum Co. in the Strategic Minerals Section, has been transferred to the Mining and Milling Dept. as mine geologist.

Robert B. Hill is now resident engineer at Gay Mine, The J. R. Simplot Co., in Pocatello, Idaho. He had been mine shift boss for Mt. Con Mine of The Anaconda Co.

Thomas W. Mitcham, consulting geologist and mining engineer, has moved his office from Flagstaff to Tuscon, Ariz. In addition to conducting his consulting business, he will give lectures for two graduate courses in geology at the University of Arizona.

J. V. LUXNER

T. W. MITCHAM

James V. Luxner graduated from the Colorado School of Mines with the degree of engineer of mines and now is employed by the Truax-Traer Coal Co. in the Kayford, Va. operations as a mining engineer. After graduation Mr. and Mrs. Luxner spent two months in Europe where they visited the Mathias Stinnes No. 125 mine in Essen and mining exhibits at the World's Fair in Brussels.

Charles W. Yetter has completed his position as president and director of Capitol Uranium, Farmington, N. M., after merging the company with Seaboard Oil & Gas Co. of Texas. He is now engaged in consulting engineering in San Francisco and has just returned from a trip to Mexico where he witnessed the reopening of an Antigua gold, silver, and lead property.

Clyde E. Weed, chairman of The Anaconda Co., right, is shown with Wilbur Jurden, who was named president of Anaconda-Jurden Associates Inc., a new wholly-owned subsidiary named in Mr. Jurden's honor. The new company offers complete architect-engineer-contractor services to industry for major plant construction, expansion, or modernization. The sizable engineering department of Anaconda will provide a nucleus for the new company. Charles A. Brinkerhoff is Anaconda's president.

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Louis H. Leitner is working for the Pennsylvania Turnpike Commission in the Mining Engineering Dept. He was formerly collier superintendent for the Pennsylvania Coal Co.

E. H. Rose of Koppers Co. Inc., Pittsburgh, was in South America for six weeks examining coal and iron mines and preparation plants this summer.

Donald S. Fulton, surveyor for Consolidated Denison Mines Ltd., has returned to college. His home is in Brighton, Ont., Canada.

K. D. Loughridge, who has been assistant general superintendent for American Smelting and Refining Co. in El Paso, Texas, has been promoted to superintendent and transferred to the East Helena plant, Mont.

M. Jordan Zimmerman spent three years in the U. S. Navy as a lieutenant and now is an engineer for Robinson Surveying Co. in Denver.

Joseph M. Marincel graduated from the University of Minnesota with a bachelor of metallurgical engineering degree and joined The Anaconda Co. in Anaconda, Mont. In another few months he will be transferred to South American operations.

John B. Rigg, formerly drill superintendent for General Minerals Corp., has become a private mine operator. He assumed the lease at Summitville, Colo., and the DMEA program for exploration of copper and lead. General Minerals Corp., before being merged with Fargo Oil Co., spent two years preparing the property for an exploration program.

Edgar A. Scholz is exploration manager for American Exploration and Mining Co. and traveled recently to examine properties in Alaska, the Philippines, Canada, Mexico, northern South America, and western U. S. Formerly he had been an independent small mine operator.

Roger E. Wakefield, who had been an engineer at Battelle Memorial Inst., now is a metallurgist for Texas-Zinc Minerals Corp. in Mexican Hat, Utah.

Duane Diekman, formerly a student at Montana School of Mines, is now geological engineer for Minerals Exploration and Research, Westport, Conn.

Clifford J. Williamson retired last March as Washington representative for American Smelting and Refining Co. He had been with Asarco for 38 years, serving as Washington representative since 1942. Mr. Williamson resides in Baltimore.

Philip D. Bleser has left the National Lead Co. to join the Orinoco Mining Co. in Puerto Ordaz, Bolivar, Venezuela.

V. H. Weatherston is chief project manager of Thiokoh Chemical Corp. Formerly he was general superintendent of operations for Braden Copper Co.

Gordon E. Frantti, who had worked for U. S. Bureau of Mines as a research engineer in Hibbing, Minn., is now geophysicist in Minneapolis since his transfer to the University campus.

J. L. SCHRODER

E. D. TIERNEY

John L. Schroder, Jr., has been named general superintendent, Lynch District, U. S. Steel Corp's Coal Div. He succeeded **T. E. Johnson** who was named special respresentative southern district of the Coal Div.

Edward D. Tierney, general superintendent of the Great Falls Reduction Dept. of The Anaconda Co., has been transferred to Butte, Mont., as assistant to Chester H. Steel, vice president of western operations.

Consolidation Coal Co., Pittsburgh, announced personnel changes that took effect in September. **J. S. Whittaker,** vice president in charge of operations of Pittsburgh Coal Co., assumed responsibility for operations at Harmar Coal Co. and Mathies Coal Co. **John L. Rozance** was appointed general superintendent of Pittsburgh Coal Co. Div. At Mathies Coal Co. a new general superintendent is **Robert D. Lauder, M. F. Florjancic** is superintendent, and **William Kebblish** is underground superintendent.

Western Gold & Uranium Inc. elected new officers: **Ralph G. Brown,** one of the founders of the company and president since 1951, has been elected chairman of the board; **Russell L. Richards,** formerly with Newmont Mining Corp. as acting general manager of O'Okiep Copper Co., was appointed president to succeed Mr. Brown. The board of directors also elected **R. V. Wyman,** general superintendent, as vice president in place of **David P. Shirra** who retired after many years of service. Mr. Shirra continues as a director. **Maurice Castagne** was named superintendent of the Orphan mine, Grand Canyon, Ariz.

B. E. GRANT

J. D. MacKENZIE

Byron E. Grant is the new general manager of Braden Copper Co. He had been assistant general manager of the Chilean subsidiary of the Kennecott Copper Corp.

John D. MacKenzie has been elected chairman of the board of American Smelting and Refining Co. to fill the vacancy caused by the death of Kenneth C. Brownell. Mr. MacKenzie will also continue as president of the company.

Ralph Tuck has recently retired as chief geologist of the U. S. Smelting, Refining and Mining Co. and is available in Salt Lake City for consulting work in mining geology.

E. P. Humphrey, president, Stonega Coke & Coal Co. and Westmoreland Coal Co., Philadelphia, has been named chairman of the program committee for the 1959 Coal Show of the American Mining Congress.

Graham W. Walkey was appointed production manager of Stanrock Uranium at Elliot Lake, Ont., Canada. He had been employed by Stanleigh Uranium Mining Co.

Willard C. Lacy, professor of geology at the University of Arizona, and **G. W. Irvin,** production superintendent and engineer, Sunrise Mining Co., Amada, Ariz., have been elected to the board of directors of Sunrise Mining Co.

T. E. JOHNSON

G. CAMPUSANO

German Campusano S. has been appointed manager of mines of the International Mining Co. in Bolivia with residence at the Chojila Mine. He was formerly general mill superintendent of the company.

E. T. Casler has been appointed executive consultant for Wellman-Lord Engineering Inc. He had recently retired as manager of International Minerals & Chemical Corp.'s Florida phosphate minerals operation.

John J. Keilen, Jr., has joined the Charleston Rubber Co., Charleston,

S. C., as director of research and development. He will direct the greatly expanded program of research, development, and testing in the company's enlarged laboratories. He had been director of development for the polychemicals division of West Virginia Pulp and Paper Co., also in Charleston.

The Dept. of the Interior's Distinguished Service Award and Gold Medal was conferred on **John H. East, Jr.**, regional director of the U. S. Bureau of Mines' eight-state Region III. It was awarded in recognition of more than 20 years of achievement with USBM in mining engineering, health and safety work, executive management, and as an author of several safety publications.

Douglas E. Newton, product manager for Western Machinery Co. in San Francisco, attended a seminar offered by the American Management Assn. at Colgate University to discuss *The Place of the Product Manager in Basic Company Organization.*

Koehler S. Stout, associate professor of mining engineering, aided Professor Vine, and two students, **Gordon R. Parker** and **Robert W. Hoy,** acted as assistants.

Dej Tewtong, formerly a student at Montana School of Mines, now is a mining engineer for the National Energy Authority in Bangkok, Thailand.

D. J. WOLFE

T. V. FALKIE

Donald J. Wolfe has been named manager of metallurgical sales for the Engineering and Construction Div. of Southwestern Engineering Co., Los Angeles.

Thomas V. Falkie, graduate student in mining engineering at Pennsylvania State University, has been selected as the recipient of one of the U. S. Steel Foundation fellowships at Penn State for 1958-59.

A course in plane surveying was conducted at Montana School of Mines, Butte, in September, with **William A. Vine,** head of the department of mining engineering, in charge.

Yee Tao Kao, mining engineer, now is associated with Mutual Trust Co. in Hong Kong. He had been employed by the Yuen Hing Mining Co. Ltd.

Martin O. Brauns is materials engineer for the Martin Co., Denver Div. Before taking this position he was a metallurgical engineer for American Smelting & Refining Co. in Wallace, Idaho.

M. I. Signer, Jr., manager of the potash division of International Minerals & Chemical Corp. Ltd., closed the Regina, Sask., office of the division and moved to a new job site at Esterhazy, Sask., where the company is constructing a potash refinery and mine involving a 3000-ft shaft.

C. J. Nelson, who was a consulting engineer for Heavy Minerals Co. in Panama City, Fla., now is an engineering aid in the U. S. Air Force.

Chester Freshour has joined the Anaconda Copper Mining Co. in Anaconda, Mont. as assistant research engineer. He had been with Wah Chang Mining Co. in Tempiute, Nev., as assistant mill superintendent.

E. J. Perry, who had been underground shift boss for Algom Uranium Mines Ltd., Nordic Div., recently became assistant chief engineer for Maritimes Mining Corp. Ltd. in Green Bay, Nfld., Canada.

William F. Stowasser, Jr., has left Allis-Chalmers Mfg. Co., where he was process development engineer, to become senior research engineer for Jones & Laughlin Steel Corp.

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Ralph E. Sinke, assistant manager of Sprostons Ltd., completed work on the construction of a 600-ton alumina plant in Jamaica and transferred to the group company, Saguenay Shipping Ltd., in Canada.

Cyril L. Spencer, who had been general manager of mines for Mauricio Hochschild & Cia, now is technical assistant to the general administrator for Anglo-Lautaro in Antofagasta, Chile.

S. K. Droubay has been elected vice president of United Park City Mines Co. and will also continue as general manager.

Charles A. Steen, president of the Utah Manufacturers Assn., won the Republican nomination for the State Senate in San Juan, Grand, and Emery Counties, Utah.

Enrique T. Barrantes-Garate has worked for the Northern Peru Mining Corp. as mine geologist in Chilete, Peru, and now is exploration geologist for the Compania de Minas del Peru at a mine of the Hochschild Organization in Arequipa, Peru.

J. D. Moore, production manager of Vitro Uranium Co., was co-author of a paper presented at the International conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, in September.

Robert G. Dwyer, intermountain area counsel for the Anaconda Co., was made director of United Park City Mines Co.

Jack H. McWilliams, geological engineer for Aluminum Co. of America since 1942, has been appointed manager of ore exploration for the company's mining division. He succeeds **A. H. Sutton,** chief geologist in the mining division of Alcoa, who resides in Columbus, Ind., and will perform special assignments in geological programs for the company.

Edwin H. Johnson, manager of the Mining Tool Div., Kennametal Inc., has been named consultant in the development and marketing of new company products in the mineral industries field. **Edgar W. Engle,** recently named manager of mineral industry products. will be responsible for the Mining Tool Div. at Bedford, Pa. Also in the division, **Edward J. Carroll** will continue as sales manager and will assume responsibility for general direction of engineering and product development. **Duane S. Saxman** will continue as chief engineer.

A. C. BIGLEY

R. S. SMITH, JR.

Arthur C. Bigley retired in September as general manager of western mining operations of The Anaconda Co. after more than four decades in the mining industry. He began his career with Anaconda as a miner at West Greyrock in 1913 and moved up the road of responsibility to the position of general manager in 1952.

Riley S. Smith, Jr., is the new chairman of the Dept. of Geology at Berea College, Berea, Ky. Dr. Smith was formerly on the staff of the University of Arizona.

George H. Deike, chairman of the board of Mine Safety Appliances Co., has been selected as western Pennsylvania's outstanding industrialist for 1958 by the Western Pennsylvania Chapter of the Soc. of Industrial Realtors. The award is given for the most significant contribution to the industrial development of Western Pennsylvania in the public interests.

Thomas N. Walthier, senior geologist at Bear Creek Mining Co., Salt Lake City, has completed a tour of operations and activities in the eastern, central, and western states, and has become assistant to the president.

Vinton H. Clarke, associate member of Behre Dolbear & Co., has been in Kerman, Iran, with **A. F. Banfield,** organizing a mineral reconnaissance of 47,000 square miles.

Robert A. Simpson, formerly a student at Michigan College of Mining and Technology, accepted the position of engineer with Reynolds Experimental Laboratory, Atlas Powder Co., Tamaqua, Pa.

Robin G. Nauta is an engineer in training with Dorr-Oliver Inc. in Stamford, Conn. He had been studying at the Colorado School of Mines.

William R. Allen, Jr., has left The Anaconda Co. in Butte, Mont., to join the U. S. Bureau of Mines Southwest Experiment Station, as a mining engineer in Tucson, Ariz.

M. E. Jackson graduated in June from the Royal School of Mines, London, England, and is now working for McIntyre Porcupine Mines Ltd. in Schumacher, Ont., Canada.

Enzo de Chetelat, who had been mining geologist for the U. S. Operations Mission to Tunisia, spent two months leave in Monsey, N. Y. He is now working at the International Cooperation Administration in Washington, D. C.

William A. Blomstran has been named district manager of the Port Henry District, Republic Steel Corp., Mineville, N. Y. The former district manager, **Francis J. Myers,** has retired. Mr. Blomstran has worked at both the Mineville and Lyon Mountain, N. Y., properties as engineer, superintendent of mines, and has done special appraisal work in Mexico and Canada, as well as the U. S.

Changes in the Du Pont subsidiaries in Mexico, Cia Mexicana de Explosives S. A. and Du Pont S. A., include the promotion of **O. H. Chavez** to manager of relations of both companies, and **Mario L. Pena** to sales manager of Cia Mexicana. Mr. Chavez had been sales manager of Cia Mexicana and had worked with important mining companies in the U. S. and Mexico before entering the explosives business. Mr. Pena will step into the sales position for Cia. Mexicana de Explosives, leaving his job as superintendent of production at the explosives plant in Dinamita, Durango.

Robert M. Hardy, Jr., president of Sunshine Mining Co., was appointed by Governor Rosellini to a three-man delegation to represent the state of Washington at the annual meeting of the Western Governors Mining advisory council in September. Other members of the delegation were **Albert Peeler,** Seattle mining operator, and **H. DeWayne Kreager,** state official.

Richard L. Stewart, assistant public relations director of the Utah Copper Div., Kennecott Copper Corp., was reappointed chairman of the membership committee, and **Miles P. Romney,** manager of the Utah Mining Assn., was reapppointed mining committee chairman of the Salt Lake City Chamber of Commerce.

Walter E. Remmers, vice president of Union Carbide Corp., has been appointed president, director, and member of the executive committee of the Pittsburgh Metallurgical Co. Inc.

Harry Bapty, mine engineer for the Torbrit Silver Mines during the past ten years, is now mine superintendent at their Alice Arm mine in British Columbia, Canada.

Don Hargrove, formerly assistant manager of Dawn Mining Co., is vice president and general manager of San Juan Gravel Products Co. in New Mexico. He was responsible for the metallurgical test work, detailed design, start up, and operation of the Dawn Mining Co. uranium plant at Ford, Wash.

Donald O. Rausch, who was an instructor at the Colorado School of

Mines, has completed the requirements for a D.Sc. degree and will receive the degree next June. He has spent the last four summers in charge of a research project in Greenland for the Snow, Ice and Permafrost Research Establishment, Corps of Engineers, U. S. Army. Now he is an engineer with Dravo Corp.

Leonid Bryner completed the requirements for his Ph.D. in geology at the University of Arizona and accepted a position as assistant professor of geology at the Colorado School of Mines. He had worked for the U. S. Geological Survey and as a geologist for Bear Creek Mining Co.

S. C. Berube, formerly central region sales manager for Le Roi Div. of Westinghouse Air Brake Co., now is special applications engineer for Hughes Tool Co.

R. G. Wayland has been staff engineer in the office of the director, USGS, and now is regional geologist for mineral land classification in the Conservation Div.

M. Mellish, formerly a student at Royal School of Mines, London, England, is working for Blyvoorvitzicht G. M. Co. Ltd., Transvaal South Africa, after obtaining his mining degree.

Lawrence A. Wing, associate professor of geology at the University of Maine, has accepted the position of chief geologist to head a new department of exploration and engineering for the James W. Sewall Co. in Old Town, Maine.

Mrs. Janice L. Jolly has become geologist for the Minerals Branch of the USGS in Beltsville, Md.

S. H. Lorain, retired from his position as regional director for Alaska for the U.S. Bureau of Mines, had been conducting consulting assignments in arctic, interior, and southeastern Alaska before going to Iran for the International Cooperation Administration. Now his consulting and mineral exploration headquarters have been moved from Juneau to Ketchikan, Alaska.

John B. White, Jr., has resigned as chief engineer for Western Knapp Engineering Co. and has accepted the position of manager of engineering in Denver for Fremont Minerals Inc. and Mines Development Co., totally owned subsidiaries of the Susquehanna Corp.

James M. Taipale, formerly a student at Michigan College of Mining and Technology, is a valuation engineer for the Bureau of Land Management, College, Alaska.

Dale A. MacDonald has been appointed sales representative in Atlas Powder Co.'s San Fransisco explosives sales district. He has been a technical representative in the Wilmington, Del., department.

Russell H. Crouse has been appointed production superintendent of Monsanto Chemical Co.'s inorganic chemicals division plant at Soda Springs, Idaho. He replaces **Wallace P. Dunlap, Jr.,** who has accepted the position as production superintendent at the Martinsville, W. Va., plant of Mobay Chemical Co., a Monsanto subsidiary.

John F. Hoffmeister has been named chief engineer of the E. J. Longyear Co. He had been vice president of Alden Elstrom Assocs., consulting engineers.

With the death of its president, **R. Eppes,** the firm of H. Straley has disposed of its business to GeoTek, Vero Beach, Fla. **H. Straley III,** who has been the firm's exploration manager for some years, will become a member of the consulting staff of the successor company, but will have no full-time connection. Those who will continue with GeoTek are: **William B. Campbell,** ceramic engineer and geologist; **Charles E. Fortson,** geologist; **Alfred T. Navarre,** geochemist; **William A. Thite,** geologist and photointerpreter; **Daniel Gates,** preparation engineer; and **James D. Ashton,** geochemist.

O. T. Hansen has been appointed mine inspector for the state of Idaho, succeeding **George McDowell** who

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recently resigned to take over a sales position with an explosives firm.

Alan E. Gallie, who has been manager of the mining and milling division of Sherritt Gordon Mines at Lynn Lake in northern Manitoba, has been transferred to Toronto to the head office where he will be assistant to the president.

David A. Brew is doing graduate work at Stanford University during the winters, and quadrangle mapping in Eureka District, Nev., during the summers, as geologist for the U. S. Geological Survey, Mineral Deposits Branch.

N. T. Gilmour, formerly manager of the Deep Lead mine of Jantar Nigeria Co. Ltd, Jos, Nigeria, is starting as an engineer senior with Mufulira Copper Mines Ltd., Mufulira, Northern Rhodesia.

Charles G. Boss is a sales engineer for Dings Magnetic Separator Co., Wauwatosa, Wis. He had been product specialist for The Quaker Oats Co., Cuyahoga Falls, Ohio.

Clarence F. Zeuch, metallurgist for Dow Chemical Co., has been transferred from Michigan to the Los Angeles sales office, servicing the southwest mining industry. His new address is Tucson, Ariz.

Hipolito Zevallos has been promoted from assistant shift foreman to shift foreman for Cerro de Pasco Corp. and has moved to La Oroya, Peru.

J. B. Mull, who was administrative assistant to the chief of geology at the Grand Junction, Colo., office of the U. S. Atomic Energy Commission, has joined the U. S. Bureau of Mines in San Francisco to head the Mineral Fuels Section.

Guy E. Ingersoll, consulting mining engineer of El Paso, Texas, recently made an examination of a mineral property in the state of Colima, Peru.

L. G. Immonen, a former concentrator superintendent, Nevada Mines Div., Kennecott Copper Corp., now is with Southern Peru Copper Corp. as a concentrator superintendent in Toquepala, Peru. For the past two years in Denver he had been working in connection with the design of the 30,000-tpd Toquepala concentrator which is now under construction.

Jacques A. Decuyper, formerly research metallurgist for Union Miniere Du Haut Katanga in the Belgian Congo, is an assistant professor in mineral dressing and extractive metallurgy at the Inst. of Metallurgy, University of Louvain in Belgium. He recently returned from an extensive study trip through the U.S. under the Belgian-American Educational Foundation of New York, visiting many research laboratories.

Victor R. Cabrera, acting mine engineer for Marcona Mining Co. in San Juan Bay, Peru, is now attending the School of Industrial Management at Massachusetts Inst. of Technology on a scholarship given by his firm.

Roger C. Fisher has graduated from the Royal School of Mines, London, and is now with New Consolidated Gold Fields Ltd., Johannesburg, South Africa.

James W. Cole has been transferred by Wah Chang Corp. from Tempiute, Nev., to Rio Grande Do Norte, Brazil.

Forrest R. Rickard was promoted from smelter engineer to general smelter foreman at the New Cornelia Branch, Phelps Dodge Corp., Ajo, Ariz.

Ciro P. De Ferari is under contract with the Ford, Bacon & Davis Inc. for the Dept. of Supervised Mining Credit Programe of Bolivia. He is working in Tupiza, Bolivia.

A. L. Brichant, technical advisor to the Directorate of mines and geology, Rabat, Morocco, has finished his assignment in Morocco and is spending some time in Belgium prior to returning to America.

Robert G. Woods, an employe of the Hayden Plant of Kennecott Copper Corp., Ray Mines Div., since 1951, has been named grinding and flotation foreman in the Hayden Concentration Mill.

Two employes of the Grand Junction Operations Office of the U. S. Atomic Energy Commission have been awarded superior performance certificates and $300 each under the AEC incentive awards program for outstanding service to the Government. They are **John W. Barnes,** chief of the planning and evaluation branch in the Source Materials Procurement Div., and **John Klemenic,** a process engineer in the same division.

Fayette Brown, Jr., has been named vice president in charge of the mining and lake transportation of iron ore for Shenango Furnace Co. His most recent position was assistant vice president for the Cleveland-Cliffs Iron Co.

James P. Reilly is now with the Corps of Engineers, U. S. Army, in Coalport, Pa., after working as an industrial engineer for Island Creek Coal Co.

Walter Riethmeier, mechanical engineer, has left the Western Knapp Engineering Co. and started work for U. S. Borax & Chemical Co., Boron, Calif.

George R. Leslie, U. S. Army Corps of Engineers, has been promoted to construction management engineer from the position of materials engineer and is stationed in Roswell, N. M.

Victor N. Hein, formerly engineering assistant for Climax Molybdenum Co., now is a structures engineer for Convair, Div. of General Dynamics, Ft. Worth, Texas.

Ernest K. Lehmann has resigned from Bear Creek Mining Co. to become a consulting geologist in private practice in Minneapolis.

Thomas I. Sharps has been transferred from Ambrosia, N. M., uranium district to the Michigan copper district where he is doing exploration work as a geologist for Calumet & Hecla Inc.

Austin L. Young, formerly a student at the University of Idaho, now is a geologist for the Dept. of Highways at Lewiston, Idaho.

R. J. Menze has been promoted from assistant division manager at Potosi, Mo., to plant manager at Kosciusko, Miss., for the Magnet Cove Barium Corp.

David L. Francis, president of the Princess Elkhorn Coal Co., Huntington, W. Va., has been reappointed as chairman of the Natural Resources Committee, Chamber of Commerce of the U. S. The Committee met in Albuquerque, N. M., in September. Other coal members of the committee are **Stanlee Hampton, H. John Harper, Harry LaViers, Edwin R. Phelps,** and **Walter F. Schulten.** Minerals and metals members are **H. Y. Bassett, Chad F. Calhoun, John C. Carrington, E. Phil Gemmer, Paul B. Jessup, W. H. Prescott, Jr., Charles E. Schwab,** and **Felix E. Wormser.**

F. M. Aimone, formerly technical representative for North American Cyanamid Ltd., now is supervisor of Canadian mining sales for Cyanamid of Canada Ltd. in Toronto.

Robert B. Hall, geologist, who has been with the mining section of United Nations Korean Reconstruction Agency in Seoul, Korea, has returned to Korea to do minerals examination work in connection with the ICA mining program for the Republic of Korea. He is employed by the Paul Weir Co. of Chicago.

Donald S. Maday, former field fire prevention engineer for the Factory Mutual Engineering Co., now is Region 3 Fire Prevention Engineer for the U. S. Government General Services Administration, Buildings Management Div., Protection Branch. The new position requires the direct supervision of fire marshalls for the protection of all Government-owned buildings within the Washington, D. C.; Maryland; Virginia; and West Virginia area.

George M. Meisel is now development engineer for Stearns-Roger Mfg. Co., Denver. He had been chief engineer and assistant manager of Colorado Iron Works.

Joseph B. Smith, formerly president of Trade Dollar Mining Syndicate, now is a valuation engineer for the Bureau of Land Management, while completing thesis requirements for a master's degree in geological engineering at South Dakota School of Mines.

Frank A. Seeton recently transferred from Grand Junction, Colo., to the company's head office in Denver to direct company mining and milling operations in Utah, Colorado, and California for Cog Minerals Corp.

J. Thiel Sullivan, who had been chief geologist for the Holly Minerals Corp., now is system research analyst for Occidental Life Insurance Co. in Los Angeles.

George D. Creelman, formerly director of research at M. A. Hanna Co., and president of Creelman Associates, consultants, now is master of physics and chemistry at the Hotchkiss School, Lakeville, Conn.

Olav Moklebust has been appointed superintendent of the pilot plant operated by R-N Corp. in Birmingham. He had been director of the Titania A/S pilot plant activities at Sokndal, Norway, which were engaged in the development of the R-N process for several years.

James Deshler, II, has resumed full time status with Minerals & Chemicals Corp. of America and has been elected chairman of the board of directors.

E. Austin was recently appointed general manager of the Hudson Bay Mining & Smelting Co. Ltd., Flin Flon, Manitoba, Canada.

Donald V. Erickson and **Russell L. Dahl,** both of the Oliver Iron Mining Div., U. S. Steel Corp., have been appointed assistant superintendent and general maintenance foreman, respectively, at the Extaca and Rouchleau ore sizing plants, Virginia, Minn., Mesabi iron range.

H. Hadley Merritt has been appointed service manager of National Mine Service Co.'s Equipment Div. He has been associated in the past with Joy Mfg. Co. and St. Joseph Lead Co.

Thomas M. Hays, geologist with Union Carbide Nuclear Co., has been transferred from the exploration department, Grand Junction, Colo., to the mining department at Uravan, Colo.

John Verhoogan, geologist on the Berkeley campus of the University of California, has been chosen to receive the Arthur L. Day Medal for 1958, one of the highest honors of the Geological Soc. of America. Mr. Verhoogan was selected for "his outstanding distinction in contributing to geologic knowledge through the application of physics and chemistry to the solution of geologic problems."

Robert R. Williams, Jr., manager of mines for Colorado Fuel & Iron Co., has been elected president of the Rocky Mountain Coal Mining Inst. Mr. Williams succeeds **Robert M. von Storch,** general superintendent of mines and quarries for the Columbia-Geneva Steel Div. of the U. S. Steel Corp. **Anthony E. Pagnotta,** CF&I, was elected Colorado's member on the Institute's board.

William B. Hall is an assistant professor in the Dept. of Geology at Montana School of Mines. He received his B.S. degree in geology at Princeton University, and an M.S. from the University of Cincinnati and is now working on his doctorate.

James E. Zane has been named market development engineer for the American Zinc Inst.

U. S. Borax & Chemical Corp. has announced the appointment of **P. J. O'Brien** as vice president, production and engineering, and **R. F. Steel** as vice president, finance and administration. The new positions were created to divide the heavy managerial responsibilities formerly centered in one office.

William M. Frames, formerly chairman of Rand Mines Ltd., has been named chairman of The International Nickel Co. S. A. (Pty.) Ltd. Mr. Frames will be chief executive officer of the South African subsidiary which is engaged in mineral exploration and investment. The company is opening new offices in the Palace Bldgs. Pritchard St., Johannesburg.

Glenn M. Hansen has been appointed process development engineer in the processing machinery department of Allis-Chalmers Manufacturing Co., Milwaukee.

Herbert P. Lee has been named general manager of Aero Service Corp., photogrammetric engineers, Salt Lake City. **John W. Strath** has been appointed sales manager of Canadian Aero Service Ltd., Ottawa, where he will direct the company's enlarged sales staff.

Troy L. Pewe, geologist-in-charge, Alaskan Geology Branch, USGS College, Alaska, was named as head of the department of geology at the University of Alaska. He will continue to work for USGS during the summer.

Robert E. Lee Hall, general counsel of the National Coal Assn., has been elected chairman of the Mineral and Natural Resources Law Section of the American Bar Assn. He has been vice chairman of the section.

D. H. Davis has been appointed assistant to D. L. McElroy, vice president of operations, Consolidation Coal Co. Mr. Davis has been operating vice president of Mathies Coal Co. for the past six years.

Bucyrus-Erie Co. announced new appointments to sales positions in the Drill Div., Richmond, Ind.: **William G. Barnes** is now sales engineer, blast hole drills; **Robert E. Cannon** is service manager; and **Mark J. Janich** is supervisor, parts and tool sales.

William Rogers Wade of Marysville, Mont., has returned from Cuba where he completed the construction of a large copper concentrator for Cia Minera Buenavista S.A.

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1957 Volume 208

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personals

continued

G. W. Mao, formerly senior research engineer for Kaiser Aluminum & Chemical Corp., has moved from California to Berwyn, Pa., to be research metallurgist for the Foote Mineral Co.

T. C. Barclay is now manager of Conmix (S. A.) Ltd., supplying premixed concrete, in Alberton, South Australia. He had been manager of Wallaroo Mount Lyell Fertilisers Ltd. in Birkenhead, South Australia.

J. H. Watson has become president-elect of the Institution of Mining and Metallurgy, London, having served as vice president from 1954 to 1957. He is chemist and assayer of the Royal Mint.

Frederick L. Smith, geologist for the Utah Mining Co., has been conducting coal exploration in the San Juan Basin, N. M., for Utah Construction Co.

W. A. Anikouchine is doing graduate work at the University of Washington after a year and a half as geologist for Cia Minera Y Refinadora Mexicana S. A.

Charles W. Fortson is a research assistant in geology at Georgia Inst. of Technology, Atlanta. He had been a graduate student at North Carolina State College.

Frank A. Crowley has joined the staff of the Montana Bureau of Mines and Geology in Butte. He recently received an M.S. in geological engineering from the Montana School of Mines. He has worked for the Bureau as assistant geologist and was a graduate assistant in the Dept. of Geology while earning his degree.

H. A. Schrecengost has been promoted to technical assistant for the U. S. Bureau of Mines and transferred to Arlington, Va. He had been supervising inspector.

Theodore O. Price, mine geologist for The New Jersey Zinc Co., has joined the Lucky Mc Uranium Corp. and moved from Gilman, Colo., to Riverton, Wyo.

R. H. Ashlock, of McFarland and Hullinger, has become superintendent of an iron project for Southwestern Engineers, under contract. He had been superintendnt for Continental Mine. He will now be located in Reno, Nev.

Wing L. Lew has been promoted to assistant to the president of Cia Minera Aguilar S.A., with headquarters in Buenos Aires, Argentina. He had been general superintendent.

John F. Haynes, manager, foreign exploration, for Utex Exploration Co., Moab, Utah, will be in Central America during the development of a Au-Ag property in southern Honduras.

Morris T. Worley received a B.S. in mining engineering at the New Mexico Inst. of Mining & Technology and is now an instructor at the Missouri School of Mines and Metallurgy in Rolla, Mo.

Roger Pemberton has been appointed senior technical representative to the mining industry for Canadian Aero Service Ltd.

Byron C. Hardinge was recently appointed chief metallurgist for Magnet Cove Barium Corp., Malvern, Ark. Before joining Magcobar in 1957, Hardinge served as development engineer for Hardinge Co. Inc., York, Pa., and also the U. S. Bureau of Mines.

Robert H. Read, formerly assistant supervisor of the powder metallurgy section, at the Armour Research Foundation of Illinois Institute of Technology, Chicago, has been promoted to supervisor of powder metallurgy research at the Foundation.

Gordon A. Paul, comptroller, American Steel & Wire Div. of United States Steel Corp., Cleveland, was recently elected to membership in the Comptrollers Institute of America.

P. E. Fedeles has been appointed as sales engineer for the metalworking industry in Western Michigan by Latrobe Steel Co., Latrobe, Pa.

I. K. Hearn, assistant general manager, Utah Copper Div., Kennecott Copper Corp., was the recipient of a national award at Los Angeles on behalf of the Salt Lake Chapter of the American Institute of Industrial Engineers.

Raymond D. Magorien, previously foreman with Kaiser Aluminum and Chemical Corp., has joined Olin Mathieson Chemical Co., as superintendent, finishing dept.

N. Harvey Collisson was recently elected president of Ormet Corp., the primary aluminum producing company jointly owned by Olin Mathieson Chemical Corp., and Revere Copper and Brass Inc. He previously was corporate vice president of Olin Mathieson for production and engineering.

Eugene S. Machlin, professor of metallurgy at Columbia University, New York City, has been appointed associate research director of the Materials Research Corp. in Yonkers, N. Y.

Necrology

Date Elected	Name	Date of Death
1940	Mason L. Bingham	Sept. 4, 1958
1930	George H. Corey	Nov. 11, 1958
1928	G. P. Crutchfield	June 10, 1958
1953	E. D. Flournoy	Unknown
1925	Laurence F. Hearne	1956
1936	H. W. Hentschel	Oct. 20, 1958
1942	W. D. Hubler	Sept. 20, 1958
1943	J. E. Jewell	July 9, 1958
1905	Henry Krumb	Dec. 27, 1958
1952	Fred T. Mathews	Unknown
1923	Merton W. Sage	Nov. 11, 1958
1916	John S. Stewart	Oct. 14, 1958
	Roger L. Strobel	Unknown

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Society of Mining Engineers of AIME

Total AIME membership on Sept. 30, 1958, was 30,654; in addition 3,131 Student Members were enrolled.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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James C. Ternahan, Jr., Riverton, Wyo.

Obituaries

A. J. Anderson (Legion of Honor Member 1903) died on July 14, 1958. He had been born in San Francisco in 1878 and was graduated from the University of California School of Mines in 1900. He began his career in mines and mills in Utah, Idaho, and Nevada and later was assistant engineer in Nicaragua. Mr. Anderson was in charge of operations at various units in Mexico for American Smelting and Refining Co. and later became manager of Moose Mountain Ltd. in Ontario. Mr. Anderson also worked in Venezuela before settling in San Francisco and Petaluma, Calif.

Thomas M. Bains (Member 1944) died on Aug. 14, 1958, in Napa, Calif. His varied career included service in the Spanish American War, the Boxer Rebellion, and World War I during which he was a major in the Infantry. After his Army service he studied at Cornell and Columbia and later worked in various mines in the west. Mr. Bains was principal economist in the tin, lead, and zinc section of the War Production Board during World War II. In 1945 he settled down in the mining industry in California.

Samuel Barker, Jr. (Legion of Honor Member 1900) died July 20, 1958. He was resident engineer for Butte Copper & Zinc Mining Co. and had been associated with Grey Eagle Mining Co. Earlier he had been a partner in the engineering firm of Wilson and Gillie. Mr. Barker was born in England in 1869 and attended the College of Montana where he received an E.M. degree in 1895. He was honored in 1950 by the Institute and Montana Section when he became a member of the Legion of Honor.

Ernest A. Brown (Member 1953) died May 15, 1958, at his home in Ottawa. He was chief of the radioactivity division, Mines Branch, Dept. of Mines and Technical Surveys. Born in Melville, Sask., in 1916, he attended the University of Manitoba, receiving B.Sc. and M.Sc. degrees, and earned a Ph.D. at McGill University in 1940. With the National Research Council Mr. Brown was senior research assistant and assistant research chemist, before joining the Mines Branch.

Kenneth C. Brownell (Member 1942), chairman of the board and chief executive officer of the American Smelting and Refining Co., died Aug. 4, 1958. He joined the company in 1927, became vice president in 1936, and president in 1947. Mr. Brownell was a director of Revere Copper and Brass Inc., General Cable Corp., and the Chase Manhattan Bank of New York, among other firms. His home was in Greenwich, Conn. He was a 1925 graduate of Yale and attended the Harvard Graduate School of Business Administration. In addition, he served as a trustee of the Rockefeller Inst. for Medical Research and was vice president of the John Simon Guggenheim Memorial Foundation.

Henry W. Bauer (Member 1944) passed away on May 21, 1958. He was born in Buchtel, Ohio, in 1903 and was a registered professional mining engineer. From 1924 to 1927 he worked for the Hutchinson Island Creek Coal Co. before beginning his association with the West Virginia Coal & Coke Corp. where he worked for many years. He became, successively, mechanical engineer, assistant chief engineer, chief engineer in 1940, and three years later executive assistant to the vice president. In 1955 Mr. Bauer became chief engineer of the Boone County Coal Corp. in Sharples, W. Va.

William L. Creden (Member 1914) died in February 1958, at the age of 88. He was born in Boston and educated at Massachusetts Inst. of Technology. He began his career with the Union Pacific Railway and as a miner in Butte, Mont., for the Heinze interests. Mr. Creden worked for the Northern Pacific Railway examining and operating mines, and was also a consulting engineer for the Butte & Superior Copper Co., for A. B. Wolvin, W. G. Conrad, and general manager of Davis-Daly Copper Co. and other companies in the Butte area. He became managing director of Utah Apex Co., Butte Detroit, and Butte & Superior Mining Cos. In 1928 he was president of Creden Mines Corp. in Butte. In 1938 he was a research engineer for the Montana Highway Dept.

William G. Duncan, Jr. (Member 1920) recently passed away. Born in 1886 in McHenry, Ky., he was educated in Louisville and at Purdue University where he graduated with a B.S. in 1907. He first joined the W. G. Duncan Coal Co. as mining engineer and advanced to superintendent in 1916. He worked his way up in the organization until he became vice president and general manager, and in 1952 was made president.

Paul B. Earwood (Member 1942) died on Dec. 16, 1957. He was born in 1891 in Beckley, W. Va., and attended Morris Harvey College and Washington and Lee University. He began work with Beaver Coal Corp. in 1912 and was promoted to chief engineer in 1916. He had a long and successful career with Beaver Coal Corp., until his death.

William W. Elmer (Legion of Honor Member 1898) died on Mar. 1, 1957, just five days before his 85th birthday. A native of Washington, he held various positions in Idaho, British Columbia, Oregon, and Alaska, doing exploration work and gold dredging. For many years he was a consulting mining engineer in Portland, Ore.

Hilmar R. Hagen (Member 1940), chief engineer for Associated Engineers Inc., died suddenly on July 16, 1958. He had been formerly a partner and vice president and director of engineering for the Anthracite and Bituminous Construction and Engineering Co. of St. Clair, W. Va. He was born in Koege, Denmark, and graduated from the Royal Danish Naval Academy with a B.S. in mechanical engineering in 1918. Mr. Hagen continued to study at the Westinghouse Extension School and Carnegie Inst. of Technology. From 1918 to 1925 he sailed aboard Danish ships as chief engineer. He was in charge of building harbor and dock facilities for a time in South America. Then in the U. S. he held various positions for U. S. Steel, Westinghouse, and the former Philadelphia and Reading Coal and Iron Co. where he was in charge of the Mechanical Engineering Dept.

Robert Hawxhurst, Jr. (Legion of Honor Member 1905), died last spring, 1958, at a rest home in California. Born in San Francisco in 1873, he attended the University of California and Stanford. He spent a number of years doing engineering and geological work in Central and South America, Hawaii, the Philippine Islands, China, and the East Indies. He was consulting mining engineer to the Charles Kaufman interests in London at one time. Mr. Hawxhurst later was a consultant in San Francisco.

Ott F. Heizer (Member 1914) passed away on May 19, 1958. He was born in Staunton, Va., in 1881 and attended the School of Mines at the University of Nevada. He was superintendent of the Sheepranch mine in California from 1916 to 1918, and manager of the Grizzly Mining Co. until 1925, before becoming general manager of the Nevada Massachusetts Co. in Mill City, Nev. He later resided in Los Altos, Calif.

Edward H. Hoag (Member 1928) died in June 1958. He was born in San Francisco in 1875 and graduated from the University of California with a B.S. in 1897. Mr. Hoag was well known in the west coast of Mexico where he went after graduation. He was manager there of the Nuestra Senora mines in Sinaloa for many years. Mr. Hoag obtained a patent on a flotation machine and reagent, along with several other patents that added to his achievements.

Ernest Klepetko (Member 1929), metallurgist, died June 27, 1958, at Polson, Mont. A Columbia Univer-

sity graduate, he had been associated with The Anaconda Co. early in his career, and later with Combined Metals Co. at Bauer, Utah, where he developed a process for recovery of resin from Utah coal. Born at Calumet, Mich. in 1888, Mr. Klepetko went to Poland for Anaconda as metallurgical manager in 1925. From 1930 on he was consultant for several firms, including Cyprus Mines Corp., Sulphur Diggers Inc., and Combined Metals Reduction Co.

Corbin Marsh (Member 1947) died on May 25, 1958. A native of Rapid City, S. D., he attended South Dakota School of Mines. In 1928 he joined St. Joseph Lead Co. as assistant mill superintendent, Hughesville, Mont., and a year later was transferred to Bonne Terre, Mo., as chemist and testing engineer. Mr. Marsh worked as a mill superintendent in Deadwood and Trojan, S. D., before joining American Cyanamid Co. In Stamford, Conn. Mr. Marsh became chief metallurgist, National Lead Co., Fredericktown, Mo., in 1952.

Alexander A. McLeod (Member 1947) died on July 2, 1958. He was born in Victoria, Australia, in 1902 and attended the Bairnsdale School of Mines, graduating in 1920 with a degree in mining metallurgy. He gained general mining experience at the Mt. Quamby Gold Mines and later advanced from assistant surveyor to chief surveyor for Broken Hill Ltd. In 1933 Mr. McLeod was superintendent of Triton Gold Mines N. L. in Reedy, Western Australia. Later Mr. McLeod was assistant general manager of the Big Bell Mines Ltd. and then general manager of North Kalgurli Ltd.

George A. Packard (Legion of Honor Member 1892) died on July 18, 1958. He was born in Wakefield, Mass., in 1869 and graduated from Massachusetts Inst. of Technology where he earned a B.S. in mining and metallurgy. His first mine experiences were at the Elizabeth and Ely mines in Vermont and at a copper leaching plant in Arizona. This experience led to cyanide work in a process just becoming known, working in Utah and Montana partly for American Cyanamid Gold & Silver Recovery Co. In 1899 Mr. Packard went to Silverton, Colo. for the Syndicate Mining Co. Most of his career was devoted to examinations and management. He was acting professor of metallurgy at Missouri University School of Mines and manager of Raven Copper Co. in Butte, Mont., as well as spending many years in private consulting work in Boston.

William Cordes Snyder, 83 years of age, died on Sept. 24, 1958, in Greensburg, Pa. He was born in Pittsburgh and attended Harrisburg Academy. He joined the Engineering Corps of the Reading Railroad and later worked in the Mining Engineering Dept. of the Pennsylvania Coal & Coke Co. He was general manager of bituminous mines for Lehigh Valley Coal Co., and established himself as a consulting engineer until his retirement in 1948.

Erwin Vogelsang (Member 1941) was killed in an automobile accident Sept. 2, 1958, near his home in West Nyack. He was a trade authority on metals and was chairman of the tin, lead, and nonferrous metals division of the War Production Board during World War II. Mr. Vogelsang had retired early this year as a consultant of Nathan Trotter and Co., Philadelphia and New York metals exchange firm and was one of the founders and a director of the American Tin Trade Assn. A native of New York in 1882, he attended Princeton University, receiving an A.B. in 1903. He began as an ore buyer in Lima, Peru, and office manager for L. Vogelstern & Co.

Chung Yu Wang (Legion of Honor Member 1905), research director of Wah Chang Corp., died Aug. 30, 1958. He was an authority on nonferrous metals and built the first antimony refinery in China. He was Commissioner of Commerce and Industry in Canton in 1912, and served as delegate on many important government and industrial boards. Born in Hong Kong, Dr. Wang graduated from Queens College, Peiyang University, and studied in Europe and at the University of California and Columbia University.

Henry Russel Wardwell

An Appreciation By
Abbott Charles

Henry R. Wardwell (Member 1938) was born in Detroit on May 19, 1913, and died Nov. 15, 1958, in Grand Junction, Colo. He spent his early youth in Grosse Pointe, just outside of Detroit, and in his early teens suffered an illness, the treatment of which first brought him to the Western country that he loved so much. Following the illness, he attended Los Alamos Ranch School in New Mexico, graduating in 1932. From there he returned to the East, attending Williams College in Massachusetts, where he pursued his interest in science and geology. Following his graduation in 1936, Henry decided to become a rock man. He returned to the West for training as a mining geologist. He received an M.S. in geology from the University of Arizona in 1941, and started his professional career at Morenci, Ariz., as a geologist for Phelps Dodge.

While in Morenci, Hank met his wife, Marjorie, who was teaching school in this little mining town and here their first child, daughter Judy, was born. After Pearl Harbor, the mining industry was a crucial part of our defense and Hank moved to Grand Junction to take part in the vital uranium exploration on the Colorado Plateau. Their first son, Bill, was born in Grand Junction during this period. Henry was with Union Carbide for four years in various capacities. He then moved to Superior, Ariz., to go with Magma Copper Co. as assistant chief geologist, where he remained 3½ years. David, their youngest child, was born there in 1948.

The Government was calling for experienced men who were familiar with the Colorado Plateau in 1951, so he returned to Grand Junction with his family and worked for the AEC for five years, through the important time when uranium sources and mills were being developed. At the completion of his special project for the Government, he returned to Union Carbide early in 1957 to take part in the guidance of their geological activities.

Through all these years, he had an intense interest in civic and professional activities. He expressed this in many services he gave and the outstanding leadership he showed. He was largely responsible for the formation of the AIME Colorado Plateau Section, and worked for its development into one of the outstanding Sections of the Institute. Hank served in many major offices and was elected chairman of the Section in 1954. He was a Section Delegate to the Annual Meetings for many years. At the time of his death, Henry was serving as chairman of the fund raising committee in behalf of the United Engineering Center. He also was recently elected vice president of the Grand Junction Geological Soc.

In addition, he was vitally and actively interested in all youth organizations. He was a tireless worker for the Boy and Girl Scouts. No job was too small or too big to command his attention and meticulous work, and as he worked, he never failed to inspire his co-workers.

Hank was a man of integrity, completely conscientious and persistent, always generous and kind, giving unsparingly of his time and energy and yet saving time for his beloved family. Everywhere he went, he made new friends and always kept the old ones. Few men had such a wide and varied circle of dear friends.

Allen B. Williams (Member 1946), retired Aluminum Co. of America executive, died May 16, 1958, in Pittsburgh. Mr. Williams became vice president of Aluminum Ore Co. in 1942 and president in 1946, retiring in 1955 as general manager of Alcoa's refining division. Born in 1890 in Riverside, R. I., he attended Brown University, receiving a B.Sc. in mining engineering in 1912. He started immediately as a salesman for Alcoa.

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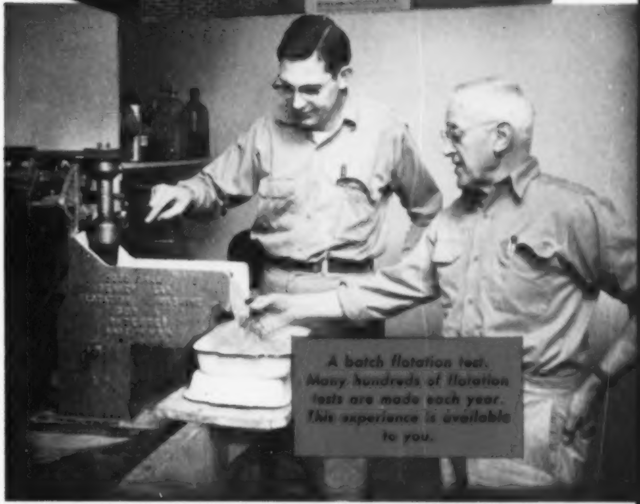

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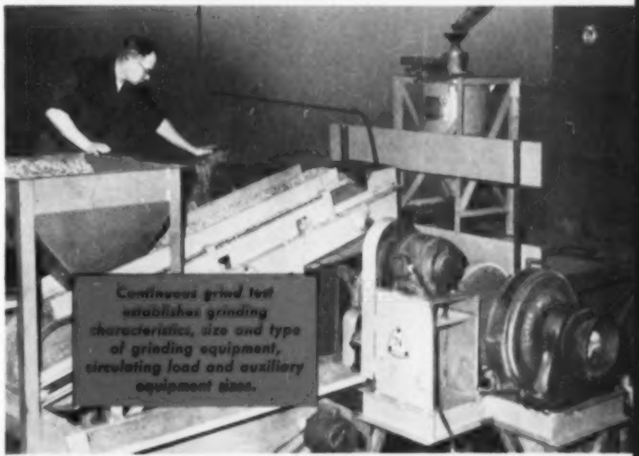

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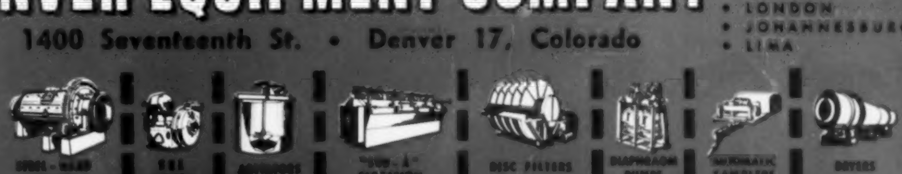

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